Vascular Plant and Vertebrate Inventory of Casa Grande Ruins National Monument

Final Report
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Cover photo of the Casa Grande structure, Casa Grande Ruins National Monument, Arizona.

In Memoriam

Eric Wells Albrecht
1970-2004

This report is dedicated to Eric's life and work; he was an extraordinary ecologist, community member, father and partner. Eric was co-coordinator of the University of Arizona (UA) biological inventory and monitoring program from 2002 until his sudden and unexpected death on September 24, 2004. Eric was near completion of his MS degree in Wildlife Conservation from the UA. His degree was awarded posthumously in November 2004. In his last year, Eric spearheaded projects to investigate the efficiency of current monitoring programs; he was determined to use the best available information to guide vertebrate monitoring efforts in the region. He is survived by his partner, Kathy Moore, and their two young children, Elizabeth and Zachary. The lives of his children will surely be enriched by Eric's hard work on behalf of the national parks in the Sonoran Desert Network.

ACKNOWLEDGEMENTS

Thanks to Superintendents Paige Baker and Donald Spencer at Casa Grande Ruins National Monument (NM) for their support of our program. Other monument staff that supported our efforts included: Dawn Daw, Jolene Johnson, Denise Shultz, Carol West, and David Winchester. This project resulted from the collaboration of many people at the University of Arizona (UA) and the National Park Service (NPS), and was facilitated by the Desert Southwest and Colorado Plateau Cooperative Ecosystem Studies Units (CESUs). The Southern Arizona Office of NPS facilitated development of the original study plan that led directly to initiation of this project. Andy Hubbard at the Sonoran Desert Network (SDN) Inventory and Monitoring (I&M) program has been a strong and convincing advocate for continuing the role of the U.S. Geological Survey (USGS)/UA Inventory program in the I&M program. Kathy Davis at Tuzigoot and Montezuma Castle national monuments played an instrumental role in this project by providing important early initiative. Larry Norris at the Desert Southwest CESU has provided strong support for our program and spent considerable time and effort providing clear and timely administrative assistance. Matt Goode, Don Swann, and Dale Turner provided much of the early planning for this project; we are indebted to their vision and work. Much appreciation is due to the SDN I&M Board of Directors for their continued support.

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All mistakes or omissions are the responsibility of the authors.

EXECUTIVE SUMMARY

This report summarizes results of the first comprehensive biological inventory of Casa Grande Ruins National Monument (NM) in southern Arizona. Surveys at the monument were part of a larger effort to inventory vascular plants and vertebrates in eight National Park Service units in Arizona and New Mexico. In 2001 and 2002 we surveyed for vascular plants and vertebrates (amphibians, reptiles, birds, and mammals) at Casa Grande Ruins NM to document the presence (and, in some cases, relative abundance) of these species. By using repeatable study designs and standardized field techniques, which included quantified survey effort, we produced inventories that can serve as the basis for a biological monitoring program.

Of the National Park Service units in the region, no other park has experienced as much ecological change as Casa Grande Ruins NM. Once situated in a large and biologically diverse mesquite bosque near the perennially flowing Gila River, the monument is now a patch of sparse desert vegetation surrounded by urban and commercial development that are rapidly replacing agriculture as the dominant land use in the area. Roads, highways, and canals surround the monument. Development, and its associated impacts, has important implications for the plants and animals that live in the monument. The plant species list is small and the distribution and number of non-native plants appears to be increasing. Terrestrial vertebrates are also being impacted by the changing landscape, which is increasing the isolation of these populations from nearby natural areas and thereby reducing the number of species at the monument. These observations are alarming and are based on our review of previous studies, our research in the monument, and our knowledge of the biogeography and ecology of the Sonoran Desert. Together, these data suggest that the monument has lost a significant portion of its historic complement of species and these changes will likely intensify as urbanization continues.

Despite isolation of the monument from nearby natural areas, we recorded noteworthy species or observations for all taxonomic groups:

- Plants: night-blooming cereus
- Amphibians: high abundance of Couch's spadefoot toads
- Reptiles: high abundance of long-nosed snakes
- Birds: 10 species of diurnal raptors including 4 species of falcons
- Mammals: American badger

This study is a first step in the process of compiling information about the biological resources of Casa Grande Ruins NM and surrounding areas, and our findings should be viewed as the state of the knowledge at this time, rather than as the final authority on plants and animals of the monument. We recommend additional inventory and research studies, and we identify aspects of our effort that could be improved upon through application of new techniques or by extending the temporal (and possibly spatial) scope of our research.

Table A. Summary results of vascular plant and vertebrate inventories at Casa Grande Ruins NM, 2001 and 2002.

Taxonomic group	Number of species recorded	Number of non-native species	Number of new species added to monument list[a]
Plants	60	12	21
Amphibians and reptiles	14	0	13
Birds	82	3	70
Mammals	13	2	7
Totals	**169**	**17**	**111**

[a] Species that had not been observed or documented by previous studies.

CHAPTER 1: INTRODUCTION TO THE BIOLOGICAL INVENTORIES

The unnamed is the heaven and earth's origin;
Naming is mother of ten thousand things.
Lao Tzu

PROJECT OVERVIEW

Inventory: A point-in-time effort to document the resources present in an area.

In the early 1990s, responding to criticism that it lacked basic knowledge of natural resources within parks, the National Park Service (NPS) initiated the Inventory and Monitoring Program (NPS 1992). The purpose of the program is to increase scientific research in NPS units and to detect long-term changes in biological resources (NPS 1992). At the time of the program's inception, basic biological information, including lists of plants and animals, were absent or incomplete for many parks. In fact, as of 1994, more than 80% of national parks did not have complete inventories of major taxonomic groups (Stohlgren et al. 1995). Inventory data were particularly lacking for smaller parks (such as Casa Grande Ruins National Monument [NM]), many of which were created to protect cultural resources, but which also contain important natural resources.

Species inventories have both direct and indirect value for management of the monument. Species lists facilitate resource interpretation and visitor appreciation of natural resources. Knowledge of which species are present, particularly sensitive species, and where they occur is critical for making management decisions (e.g., locating new facilities). Inventories are also a cornerstone of long-term monitoring. Thorough biological inventories provide a basis for choosing parameters to monitor and can provide initial data (i.e., a baseline) for monitoring ecological populations and communities. Inventories can also test sampling strategies, field methods, and data collection protocols, and provide estimates of variation that are essential in prospective power analyses.

Goals

The purpose of this study was to complete basic inventories for vascular plants and vertebrates at Casa Grande Ruins NM. This effort was part of a larger biological inventory of eight NPS units in southern Arizona and southwestern New Mexico (Davis and Halvorson 2000, Powell et al. 2002, 2003, 2004).

The goals of our biological inventory of Casa Grande Ruins NM were to:

1. Conduct field surveys with the goal of documenting at least 90% of all species of vascular plants and vertebrates expected to occur at the monument.
2. Use repeatable sampling designs and survey methods (when appropriate) that allow estimation of parameters of interest (e.g., relative abundance by taxonomic group) with associated estimates of precision.
3. Compile historic occurrence data for all species of vascular plants and vertebrates, from three sources: museum records (voucher specimens), previous studies, and monument records.
4. Create resources useful to monument managers, including detailed species lists, maps of study sites, and high-quality digital images for use in resource interpretation and education.

The bulk of our effort addressed goals number 1 and 2. To maximize efficiency (i.e., the number of species recorded by effort) we used field techniques designed to detect multiple species. We did not undertake single-species surveys for threatened or endangered species. Finally, although pest species are a significant management concern at the monument (NPS 1997), we did not evaluate habitat use and therefore cannot comment on the relative contribution of species to the degradation of the monument's cultural resources (e.g., Swann et al. 1994).

Administrative History

The original study plan for this project was developed, and an inventory of one Sonoran Desert Network (SDN) park (Tumacácori National Historical Park) was completed, through a cooperative agreement between NPS, UA, and the USGS. This project comprises biological inventories for seven additional parks and was funded through Task Agreements UAZ-03, -05, and -06 (under Colorado Plateau CESU cooperative agreement number 1200-99-009). The National Park Service thereafter obligated additional funds for administration, management, and technical oversight of the biological inventories through the Colorado Plateau CESU (UAZ-07) and the Desert Southwest CESU (cooperative agreement number CA1248-00-002, reference UAZ-39, -77, -87, -97, and -128).

Report Format and Data Organization

This report includes summaries and analyses of data related to vascular plants and vertebrates (amphibians, reptiles, birds, mammals) collected from 2001 and 2002 at Casa Grande Ruins NM. This report is intended to be useful in internal planning processes and outreach and education, and as such we strive to make it relevant, easy to read, and well organized. We report only common names (listed in phylogenetic sequence) unless the species is not listed later in an appendix; in this case we present both common and scientific names. For each taxonomic group we include an appendix of all species that we recorded in the monument (Appendices A–D), and vertebrate species that were likely present historically or that we suspect are currently present and may be recorded with additional survey effort (Appendices E–G). Species lists are in phylogenetic sequence and include taxonomic order, family, genus, species, subspecies or varieties (if applicable) and common name. Scientific and common names used throughout this document are current according to accepted authorities for each group: Integrated Taxonomic Information System (ITIS 2004) and the PLANTS database (USDA 2004; including designation of plants as "non-native") for plants; Stebbins (2003) for amphibians and reptiles; American Ornithologist Union (AOU 1998, 2003) for birds; and Baker et al. (2003) for mammals. To maintain consistency throughout the document, we do not capitalize the first letter of common names unless they are proper names. In this document we use the International System of Units for measurements.

Spatial Data

Most spatial data are geographically referenced to facilitate mapping of study plots and locations of plants or animals. Coordinate storage is the Universal Transverse Mercator (UTM) projection, using North American datum 1983 (NAD 83), Zone 12. We recorded most UTM coordinates using hand-held Garmin eMap® Global Positioning System (GPS) units (Garmin International Incorporated, Olathe, KS; horizontal accuracy is about 10–30 m) because of their convenience and relative simplicity. We obtained some plot or station locations by using more accurate Trimble Pathfinder® GPS units (Trimble Navigation Limited, Sunnyvale, CA; horizontal accuracy about 1 m). Unless otherwise noted in the appendices, coordinates were obtained with eMap units. It should be noted that not all UTM coordinates reported are accurate representations of the plant or animal location. For example, UTM coordinates associated with plot-based detections are for the plot corners (Appendices H–J). Bird sightings are another exception; the UTM coordinates are reported for survey stations or transects, but the animals we detected were typically up to 150 m distant (in rare cases as far away as 300 m). For each taxon-specific chapter of this document we mapped the location of all plots or stations overlaid on Digital Orthophoto Quarter Quads (DOQQ; produced by the U.S. Geological Survey).

Species Conservation Designations
We indicate species conservation designations by the following agencies: U.S. Fish and Wildlife Service (responsible for administering the Endangered Species Act), Bureau of Land Management, USDA Forest Service, Arizona Game and Fish Department, and Partners in Flight (a partnership of federal, state and local governments, non-governmental organizations, and private industry that supports bird conservation initiatives).

Databases and Data Archiving
We entered field data into taxon-specific databases (Microsoft Access version 97) and checked all data for transcription errors. From these databases we reproduced copies of the original field datasheets using the "Report" function in Access. The output looks similar to the original datasheets but all data are easier to read. The databases, printouts, and other data such as digital photographs and GIS layers will be distributed to monument staff, associated cooperators, and to the following data repositories:

- Southern Arizona Office, National Park Service; Phoenix, Arizona
- University of Arizona, Special Collections, Main Library; Tucson, Arizona

Original copies of all datasheets will be given to the NPS SDN I&M program office in Tucson and may be archived at an another location. This redundancy in data archiving is to ensure that these valuable data are never lost. Along with the archived data we will include copies of the original datasheets and a guide to filling out the datasheets. This information, in conjunction with the text of this report, should enable future researchers to repeat our work.

Verification and Assessment of Results

Photo Vouchers
Whenever possible we documented vertebrate species with analog color photographs. Many of these photos show detail on coloration or other characteristics of visual appearance, and they may serve as educational tools for the monument staff and visitors. Photographs will be archived with other data as described above.

Voucher Specimens
In many cases we collected voucher specimens to verify identifications and document species presence. Before taking vertebrate voucher specimens, we searched for existing vouchers from Casa Grande Ruins NM in records from 48 natural history museums (Appendix K; see Appendix L for results). When we collected specimens we used individuals that were killed incidentally (e.g., roadkill) whenever possible, but we occasionally euthanized animals, particularly when identification was uncertain (e.g., many small-mammals exhibit subtle variations in pelage color patterns within species and external-measurement overlap among species). The University of Arizona's Institution for Animal Care and Use approved all field protocols for euthanizing animals (Protocol Control Number 03-177), and all specimens were prepared according to standardized techniques and accessioned into the appropriate vertebrate collection at the University of Arizona (vertebrate vouchers are listed in Appendix M). We collected specimens and conducted research under the following permits: U.S. Fish and Wildlife Service Salvage Permit MB042554-0, and National Park Service Scientific Research and Collecting Permit CAGR-2001-SCI-0001, study number CAGR-00001.

For plants, we searched the University of Arizona herbarium for existing specimens from Casa Grande Ruins NM (see Appendix A for results), but we collected herbarium specimens whenever flowers or fruit were present on plants in the field (Appendix A). All specimens that we collected were accessioned into the University of Arizona herbarium.

Assessing Inventory Completeness

Inventory completeness can most easily be assessed by (1) examining the rate at which new species were recorded in successive surveys (i.e., species accumulation curves; Hayek and Buzas 1997) and (2) by comparing the list of species we recorded with a list of species likely to be present based on previous research and/or expert opinion. For all species accumulation curves, we randomized the order of the sampling periods to break up clusters of new detections that resulted from temporal conditions (e.g., monsoon initiation) independent of cumulative effort.

TECHNICAL CONCEPTS

This section introduces some technical concepts and considerations related to our research at Casa Grande Ruins NM. A glossary, where we define common terms used in this document, follows the Literature Cited chapter.

Habitat

Habitat is a species-specific term referring to an area with resources and environmental conditions promoting occupancy, survival, and reproduction of that species (Morrison et al. 1998). Thus, referring to an area as "creosote habitat" indicates that the area supports this plant species, not that it supports a host of other species that may be (or in some times/locations may not be) associated with creosote.

Sampling Design

Sampling design is the process of selecting sample units from a population or area of interest (for a review, see Thompson [1992]). Unbiased random samples allow inference to the larger population from which those samples were drawn, and estimate the true value of a parameter. The precision of these estimates, based on sample variance, increases with the number of samples taken; theoretically, random samples can be taken until all possible samples have been selected and precision is exact – a census has been taken and the true value is known. Non-random samples are less likely to be representative of the entire population, because the sample may (intentionally or not) be biased toward a particular characteristic, perhaps of interest or convenience.

We briefly address sampling design in each chapter. In general our survey plots were not randomly located because we were more interested in detecting the maximum number of species than in providing inference to a larger area. Thus, abundance estimates (relative abundance, useful as an index to true abundance) detailed in this report may be biased because we surveyed in areas likely to have high species richness; however, the nature or extent of that bias is difficult to characterize or quantify. If population estimates were a higher priority, avoiding this potential bias would have greater importance.

Estimates of Abundance

Estimating population size is a common goal of biologists, generally motivated by the desire to reduce (e.g., pest species), increase (e.g., endangered species), maintain (e.g., game species) or monitor (e.g., indicator species) population size. Our surveys at Casa Grande Ruins NM were generally focused on detecting species rather than estimating population size. In many cases, however, we present estimates of "relative abundance" by species, which is an index to population size; we calculate it as the number of individuals of a species recorded, scaled by survey effort. Some researchers (particularly plant, marine, and invertebrate ecologists) prefer to scale such frequency counts by the number of observations of other species, which provides a measure of community dominance; abundance relative to other species present. If we completed multiple surveys in comparable areas (e.g., anywhere within

Casa Grande Ruins NM), we included a measure of precision (usually standard error) with the mean of those survey results.

Indices of abundance are presumed to correlate with true population size but do not typically attempt to account for variation in detectability among different species or groups of species under different circumstances. Metrics (rather than indices) of abundance do consider variation in detection probability, and these include density (number of individuals per unit area; e.g., two long-nosed snakes per hectare of creosote flats), and absolute abundance (population size; e.g., 148 western whiptail lizards at Casa Grande Ruin NM). These latter techniques are beyond the scope of our research. While it is true that indices to abundance have often been criticized (and with good reason, c.f. Anderson 2001), the abundance information that we present in this report is used to characterize the commonness of different species rather than to quantify changes in abundance through space (e.g., habitat-use studies) or time (e.g., monitoring). As such, relative abundance estimates are more useful than (1) detectability-adjusted estimates of density for only a few species or (2) raw count data for all species without scaling counts by search effort. For a review of methods used to estimate abundance, see Lancia et al. (1996).

CHAPTER 2: MONUMENT OVERVIEW

MONUMENT AREA AND HISTORY

Casa Grande Ruins NM is located in Coolidge, Arizona, approximately 70 km southeast of Phoenix (Fig. 2.1). The monument currently encompasses 191 contiguous ha, but managers are proposing to increase the size of the monument by approximately 105 ha (including 32 ha adjacent to the current site [NPS 2003a])[1].

Casa Grande Ruins NM was created to protect the Casa Grande, a four-story adobe structure that was built by the Hohokam between AD 1200 and 1450 (Clemensen 1992). The Hohokam had a sophisticated culture—they built extensive canals to irrigate crops and provide water to large communities in the vicinity of the Casa Grande. After the mysterious departure of the Hohokam in approximately 1450, the Casa Grande stood abandoned for nearly 450 years until, in 1892, the structure and the land surrounding it became the first U.S. prehistoric cultural site to receive federal protection (Clemensen 1992). In 1918, Casa Grande Ruins became part of the National Park Service system by the proclamation of President Woodrow Wilson. Today the monument hosts approximately 120,000 visitors per year (NPS 2004).

NATURAL RESOURCES OVERVIEW

Physiography, Geology, and Soils

The monument is located approximately 1 km south of the Gila River, which now only flows seasonally. The Pima Lateral canal runs parallel to (and a few meters from) the southern boundary of the monument and a smaller irrigation ditch parallels the west boundary (Fig. 2.2). Highway 87 runs along the east and north boundaries of the monument.

The monument is situated at approximately 430 m above sea level in the Basin and Range Physiographic Province, which is characterized by gently sloping valley floors surrounded by mountain ranges. The monument is characterized by Quaternary and Tertiary alluvial deposits (fluvial and lacustrine) from the surrounding mountain ranges: San Tan Mountains (six km north), Sacaton (16 km west), Picacho (30 km southeast), and Casa Grande (30 km southwest). The mountains bordering the valley floor are composed of non-water-bearing Precambrian granite, gneiss, and schist (Van Pelt 1998). All mountain ranges are isolated from each other by agriculture and development. Soil at the monument is Coolidge sandy loam, with caliche two to four feet below the surface.

Hydrology

The Gila River is the main water body in the region, but impoundments upstream from the monument cause the river to run dry for most of the year in the reach to the north of the monument. Irrigation canals carry water for crops, while water for developments comes from groundwater pumping (Sprouse et al. 2002). Pumping has significantly impacted the vegetation composition and structure of the monument (see section below on natural resource issues; Van Pelt 1998) and poses the threat of soil subsidence and fissure development for the Casa Grande.

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[1] Because we did not include the proposed expansion lands in our surveys we cannot make inference to plants and animals present in those areas; however it is likely that resources are similar in locations with similar conditions and influences that are near to the current monument.

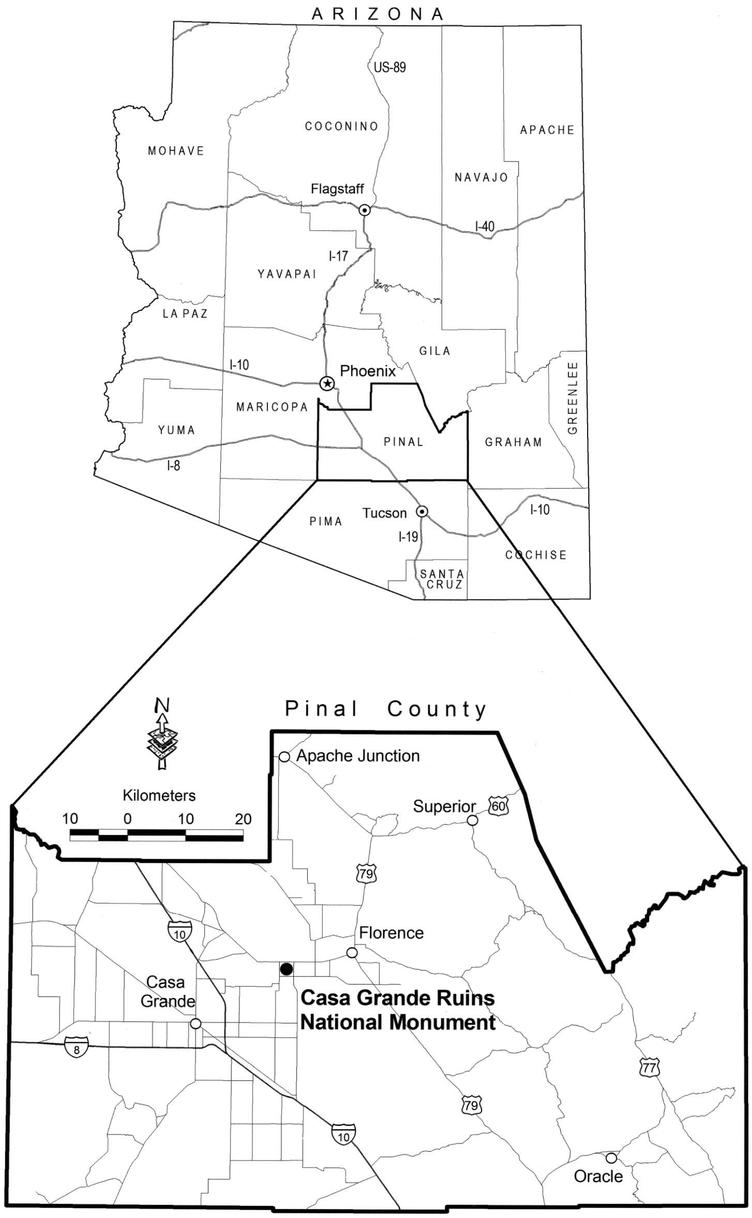

Figure 2.1. Location of Casa Grande Ruins National Monument, Arizona.

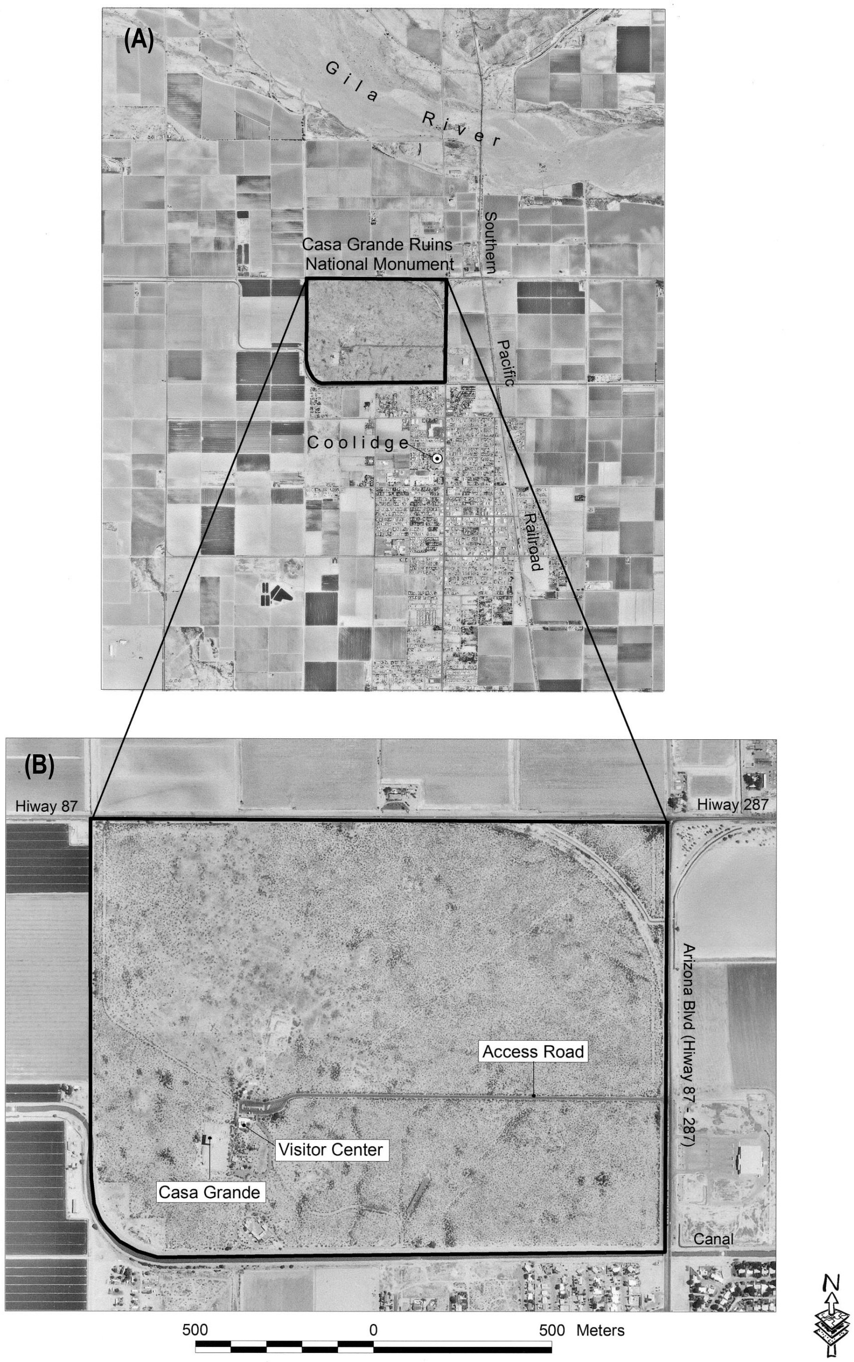

Figure 2.2. DOQQ image (1997) of Casa Grande Ruins NM showing it in a patchwork of commercial and residential development and agricultural fields (A) and a more detailed image of the monument's major features (B).

Climate

Casa Grande Ruins NM is located in the subtropical desert climatic zone of southern Arizona, which is characterized by heavy summer (monsoon) storms brought about by moisture coming from the Gulf of Mexico and less intense, frontal storms from the Pacific Ocean in the winter. The monument receives an average of 23 cm of precipitation annually (Table 2.1; WRCC 2004). Summers in the area are hot; daily maximum temperatures from June through September often exceeded 40 ^{o}C. Winters are mild and temperatures rarely drop below freezing (Table 2.1; WRCC 2004).

Average annual precipitation totals during the course of our study were slightly above the long-term mean of 22.8 cm in 2001 (24.7 cm) but considerably lower than average in 2002 (12.2 cm), which was one of the driest years on record (Fig. 2.3; WRRC 2004). In the fall of 2000 rainfall was above average (Fig. 2.3); this rain may have increased winter annual plant seed germination and growth prior to our 2001 spring plant surveys. Average annual temperatures during both years of our study were 0.9 ^{o}C above the long-term mean of 20.8 ^{o}C.

Vegetation

Current Conditions

The relatively homogenous vegetation community at Casa Grande Ruins NM is characterized as Sonoran desertscrub dominated by creosote with scattered velvet mesquite, saltbush and annual grasses and forbs (Reichhardt 1992). Shrubs and trees in the vicinity of the visitor center are irrigated, and the many standing dead velvet mesquite trees in other areas of the monument reference a change from historic conditions.

Historic Conditions

Because the area in and around the monument has been intensely used for hundreds of years, it is difficult to determine the “natural” vegetation community of the area. Given the monument’s close proximity to the Gila River, coupled with the topographic and soil conditions of the site, it is likely that the area was once a vast mesquite bosque, especially before colonization by the Hohokam. Even since the abandonment of the area by the Hohokam, many large mesquite trees dominated the area, as noted by late 19th Century visitors (Clemensen 1992). Subsequent cattle grazing probably enabled the increase in woody shrubs such as creosote, catclaw acacia, and saltbush (Clemensen 1992). However, in the mid- to late-1930s, the large mesquites at the monument began to die off, apparently due to a drop in the groundwater level related to over-pumping for agricultural irrigation (Judd et al. 1971, Clemensen 1992, Nickens 1996). The die-off of mesquites likely changed the water retention capacity of the soil, leading to the die-off of salt bush and catclaw acacia, thereby creating conditions favorable to proliferation of creosote, which now dominates at the monument.

Historic Land Use of the Monument and Surrounding Areas

Clemensen (1992) compiled a detailed history of Casa Grande Ruins NM and the following information comes from his work. Beginning in the 1870s, settlers began grazing cattle in the area because of the abundant forage. Grazing continued until 1934 when the monument was fenced to exclude cattle. But it was agriculture that would become the dominant land use, and beginning in the

Table 2.1. Average monthly climate data for Casa Grande Ruins NM, 1906–1916 and 1932–2003 (data summarized from WRCC 2004).

	Month												
Characteristic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Annual**
Maximum temperature (^{o}C)	19.6	22.1	25.2	30.3	35.3	40.5	41.5	40.3	38.2	32.1	24.7	19.7	30.8
Minimum temperature (^{o}C)	1.2	2.7	5.1	8.3	12.6	17.6	23.3	22.7	18.7	11.4	4.6	1.4	10.8
Total precipitation (cm)	2.2	2.1	2.3	0.9	0.4	0.3	2.8	3.1	2.0	1.8	1.9	2.9	22.8

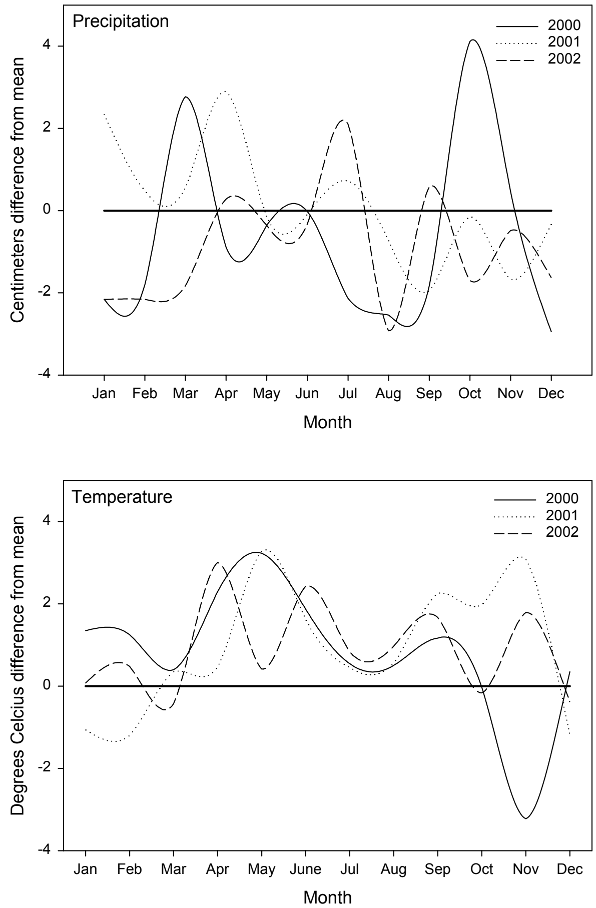

Figure 2.3. Comparison of monthly weather data during the time of the inventory (2001 and 2002) compared to the mean (1906–1916 and 1932–2003; thick, solid line in both figures; data from WRCC 2004), Casa Grande Ruins NM. Data from 2000 are included to show conditions prior to fieldwork.

1880s settlers began in earnest to clear land in the vicinity of the monument. Water for irrigating crops (fruit trees, grapes, cereal grains, cotton, lettuce, and alfalfa) came first from direct diversion of flow from the Gila River, and later from above-ground storage with the construction of nearby Coolidge Dam in the mid 1920s and groundwater accessed by pumping. In 1925 the town of Coolidge was created and by 1932 the monument was surrounded by agricultural fields. However, by 1947, agricultural fields were being abandoned because of drought and a lowered water table, due in large part to over-pumping. Depth-to-water rebounded somewhat by the late 1990s, in part because of reduced groundwater pumping (Sprouse et al. 2002).

NATURAL RESOURCE MANAGEMENT ISSUES

Casa Grande Ruins NM is an isolated patch of desert vegetation surrounded by intensively altered land; uses include agriculture, residential and commercial development, and roads. Although it is difficult to quantify the effect of these land uses, these (and other) influences inevitably affect the structure and composition of plant and animal communities in the monument.

Agriculture

Agricultural fields bordering the monument to the west and north are typical of the dominant land use in the surrounding area. These areas provide disturbed soils and only marginal space for other plants to grow, space that is typically occupied by non-native "weedy" plants including redstem stork's bill, red brome, Russian thistle, and Johnsongrass. In addition, the canals that border the monument are periodically dredged and the sediment (likely rich in non-native plant seed) is deposited along the edge of the monument boundary (Hubbard et al. 2003).

Farmers typically use pesticides and herbicides to maintain high agricultural yields, but because insects are the primary food for many animals (e.g., many species of birds rely on invertebrates during the breeding season; Ehrlich et al. 1988) the loss or contamination of this prey base can cause mortality, impaired health (e.g., decreased reproductive success or increased susceptibility to disease), and abandonment of the area in search of a viable prey base (Best 1992, Freemark and Boutin 1995, Boutin et al. 1999). Pesticides can also alter nutrient and energy flows and the chemical composition of plants (Pimentel and Edwards 1982). The overspray, or "drift" of herbicides to adjacent areas (such as the monument) following aerial application, can adversely affect non-target vegetation (Freemark and Boutin 1995), again lowering reproductive success and reducing fitness of plants and animals (Fletcher et al. 1993). Herbicides and fertilizers alter vegetation composition by favoring certain plants and killing others (Tietjen et al. 1967, Fagerstone et al. 1977). Agricultural byproducts (including sediment, fertilizers, pesticides, herbicides, and dust) can reduce air quality and contaminate surface water and groundwater (Freemark and Boutin 1995, Bohlke 2002).

Due to concern expressed by monument personnel, Currie (1998) conducted a review of pesticide and herbicide applications on lands adjacent to the monument. He found scant information on the type and extent of the aerial application of these chemicals and recommended steps for acquiring additional information. To our knowledge there has been no follow-through on his recommendations at the time of writing (2004).

Residential and Commercial Development

Casa Grande Ruins NM is located within the City of Coolidge. The city's population (7,786 inhabitants in 2000) is increasing rapidly, leading to increased residential and commercial development (NPS 2003a, 2003b). Large-scale commercial developments (e.g., Wal-Mart®) have been built along Highway 87 across from the monument. Residential development abuts the south boundary and is planned along the west boundary should the proposed monument boundary expansion not be approved. Impacts of these developments on the monument's natural resources may include: (1) an increase in non-native plants (e.g., the first sighting of a common plant used in landscaping, crimson fountaingrass, was reported by Halvorson and Guertin [2003]); (2) increased trash and run-off of sediment and toxins from vehicles; (3) disruption of animal movement patterns; and (4) increased harassment and mortality of native animals by free-roaming feral pets (Clarke and Pacin 2002). The change in land use adjacent to the monument from agriculture to urban development likely has positive aspects as well, including reduction of pesticide/herbicide overspray (though the extent of the impacts on the monument has never been established).

Roads
Casa Grande Ruins NM is completely encircled by roads, most notably Highway 87 (Fig. 2.2), the primary highway in the area. Roads act as dispersal corridors for non-native plant species, which often thrive in the adjacent disturbed soils. Roads surrounding the monument likely act as barriers to the flow of terrestrial wildlife because of direct mortality and modification of behavior (Trombulak and Frissell 2000, Clark et al. 2001, Tigas et al. 2002, Cain et al. 2003).

Changes in Land Use Type
Each species responds in different ways to the mosaic of land use types (roads, canals, agricultural fields, and development) that surround the monument. While this matrix may function as habitat for species such as house cat and domestic dog, these human-altered landscapes create barriers to movement, threats to essential resources, and occasionally direct mortality. While it is beyond the scope of this project to delineate habitat requirements of species or determinants of species composition, existing research indicates that changes such as urban development, agriculture, and road construction have significant impact on presence, abundance, and life-history functions (e.g., ability to reproduce or forage) of native plants and animals. As agricultural fields give way to commercial and high- or moderate-density residential development, the repercussions of urbanization on the native plants and animals at Casa Grande NM will likely intensify.

Groundwater Pumping
The continued pumping of groundwater for agricultural, residential, and commercial use may threaten existing mesquites on the monument despite the recent (and likely temporary) rise in the level of the groundwater (Sprouse et al. 2002). Groundwater pumping can also lead to subsidence that threatens the Casa Grande structure (NPS 1998, Richardson 2002, Hubbard et al. 2003).

Non-native and Pest Species
Awareness of non-native species as a management issue has increased in recent years; ecologists have ranked this issue with habitat loss as one of the most significant causes of species endangerment (Brooks and Pyke 2001). Non-native plant species are a significant management issue at the monument because it is surrounded by roads, agricultural fields, and development, which generally provide ideal conditions for the dispersal and establishment of some non-native plants. Non-native plants are known to alter ecosystem function and processes (Naeem et al. 1996, D'Antonio and Vitousek 1992) and reduce abundance of native species, creating potentially permanent changes in species diversity and community composition (Bock et al. 1986, D'Antonio and Vitousek 1992, OTA 1993). The Casa Grande and associated structures provide habitat for many non-native birds such as house sparrow and European starling (Chapter 5), and the adjacent developments provide a source for free-roaming and feral cats and dogs (Chapter 6).

In its Integrated Pest Management Plan (IPM; NPS 1997), monument personnel identified a number of wildlife species that are causing significant damage to the archaeological ruins in the monument. The IPM plan, along with that by Swann et al. (1994) identified round-tailed ground squirrel, rock pigeon, and house finch as the most important pest species.

CHAPTER 3: PLANT INVENTORY

PREVIOUS RESEARCH

The earliest collecting effort at the monument was from 1939 to 1942 when Natt Dodge, the regional naturalist, and Francis Elmore, a park ranger, collected plants from throughout the monument. These specimens (43 species) are at the University of Arizona herbarium (Appendix A).

Reichhardt (1992) conducted an inventory of plants at the monument in 1987. This work included a list of plants that she collected, classification of vegetation communities in the monument, creation of a checklist of non-ornamental plants, establishment of vegetation plots and sampling results, mapping of mesquite trees, and establishment of "photo points" for use in describing qualitative changes in the vegetation community. Halvorson and Guertin (2003) mapped the distribution of select non-native plant species in the monument from the fall of 1999 to the spring of 2001. Collections of plants from the monument made by additional observers have been accessioned to the herbarium at the University of Arizona and to the Western Archaeological Conservation Center in Tucson (Appendix A). Finally, we conducted vegetation sampling at plots associated with stations for breeding-season bird surveys (see Chapter 5 for methods and Appendix Q for results).

The excellent work that preceded our effort reduced the field work required for the inventory. Below-average monsoon rains in 2002 further limited our efforts because most of the species that we hoped to record are annuals that germinate following rains.

METHODS

We used "general botanizing" surveys at the monument, during which observers walked throughout the monument and opportunistically collected and recorded plants. In addition to our own results, we present here the first synthesis of findings from past studies and collections. For simplicity, we refer to all subspecies and varieties (n = 5) as species.

Spatial Sampling Design

Our survey crews walked throughout most of the monument on each visit.

General Botanizing

<u>Field Methods</u>

Whenever possible we collected one representative specimen (with reproductive structures) for each plant species. We also maintained a list of species observed but not collected. This list, along with the list of collected species, comprise a "flora" for the monument (Appendix A). When we collected a specimen we recorded the flower color, associated dominant vegetation, date, collector name(s), and UTM coordinates. We pressed the specimens on site. Specimens remained pressed for 2–3 weeks and were frozen for 48 hours to prevent infestation by insects and pathogens. We then mounted the specimens and accessioned them into the University of Arizona herbarium.

<u>Effort</u>

We made three day-long visits (typically with two observers) on 21 and 22 March 2001 and 24 September 2002.

<u>Analysis</u>

We present summary statistics regarding number of species found and number of non-native species.

RESULTS AND DISCUSSION

We recorded 60 species during our three visits to the monument, including 21 species that had not been previously documented in the monument (Appendix A). We collected 12 non-native species, all of which had been previously recorded in the monument.

We summarized data from two previous studies (Reichhardt 1992, Halvorson and Guertin 2003) and from relevant records in the collections of two herbaria (University of Arizona and Western Archeological Conservation Center) (Appendix A). Combining data from all studies and collections, including our own, there have been 127 species of plants recorded on or adjacent to the monument. This number includes cultivated trees, but not cultivated shrubs and succulents (e.g., ocotillo) around the visitor center (see Reichhardt [1992] for an explanation). There have been 31 species of non-native plants observed or documented at the monument (24% of total flora), and of these, nearly 40% (n = 12) are grasses (family Poaceae, Appendix A).

Reichhardt (1992) did not quantify effort associated with her surveys, but dated specimens indicate that she collected plants on four days in the winter and spring of 1987 (1 February, 1 and 17 March, and 9 June). Precipitation was below average for two years prior to Reichhardt's surveys (WRCC 2004), and this factor, in combination with greater search effort, may explain why the combined results of our inventory effort and surveys Halvorson and Guertin (2003) recorded a relatively high number of previously unrecorded species (n = 37 species, 12 of which are non-native; Fig. 3.1).

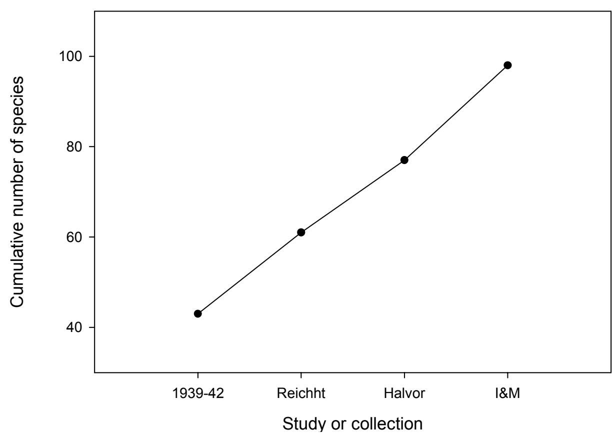

Figure 3.1. Cumulative number of new plant species found at Casa Grande Ruins NM by four separate studies or collection, from earliest collection to the most recent: "1939–42" = collection in University of Arizona herbarium; "Reichht" = Reichhardt (1992); "Halvor" = Halvorson and Guertin (2003); "I&M" = this survey effort. Figure should not be used as an estimate of the current species richness at the monument.

Alternatively, these additional species may result from a marked change in the plant community that has appears to have occurred over the last 15 years[2]. Indeed, of the 22 non-native species that Halvorson and Guertin (2003) mapped, 16 were found only along roads and/or the irrigation canal, and an additional three species were found primarily along the monument's roads. New species were detected throughout their study. There were 52 species, including six non-natives, found by prior studies but not by our crews or by Halvorson and Guertin (2003) (Appendix A), suggesting substantial shifts in vegetation composition and increased non-native occurrence during the last 60 years. The list of plants that have not been found since 1942 includes three species of shrubs (Alkali goldenbush, fairyduster, and eastern Mojave buckwheat).

Vehicles and roads may be enhancing the dispersal and establishment of new species, particularly non-native species (Seabloom et al. 2003). Increased precipitation runoff from roads may contribute to this apparent pattern (i.e., seeds are more likely to germinate in areas receiving more moisture), and soils along the monument boundary and roads are more likely to be disturbed (facilitating seed germination and plant establishment) than are soils in the monument interior.

INVENTORY COMPLETENESS

We believe that the combined effort of our study and previous studies and collections have recorded virtually all of the perennial plant species that occur at Casa Grande Ruins NM (excluding ornamentals around the visitor center). The list of annuals, however, is likely incomplete, due in part to the increasing number of non-native plants that are becoming established in the monument (Halvorson and Guertin 2003). Each study at the monument, including ours, has recorded from 11 to 21 species that were not reported by any other efforts (Appendix A; Fig. 3.1). Because most of the new species for the monument are annual forbs and grasses, these numbers highlight the importance of surveying following periods of above-normal precipitation (as we did in 2001) and to survey repeatedly.

[2] See Chapter 2 for additional information on temporal changes in the monument's vegetation community.

CHAPTER 4: AMPHIBIAN AND REPTILE INVENTORY

PREVIOUS RESEARCH

To our knowledge, there has been no inventory and scant research related to amphibians and reptiles ("herpetofauna") at Casa Grande Ruins NM, though we located three specimens collected from the monument (Appendix L) and know of several others collected in the area or region (Appendices E, N). Charles Conner, a biologist at Organ Pipe Cactus National Monument, has surveyed diurnal lizard populations at the monument for several years, but to date only a species list has been produced (Charles Conner, *pers. com.*).

METHODS

We surveyed for herpetofauna in 2001 and 2002 using four methods representing plot-based and more flexible non-plot-based methods (Table 4.1). Plot-based methods are constrained by time and area, and thus provide data for estimates of relative abundance that should unbiased by these factors. Random location of these surveys also allows inference out to the current monument boundaries. Non-plot-based surveys allow observers more flexibility in adjusting their search time, intensity, and location, and this flexibility is important for detecting rare, elusive, or ephemeral species more likely to be missed using plot-based surveys. We used both diurnal and nocturnal surveys in an effort to detect species with restricted periods of activity (see Ivanyi et al. 2000, Stebbins 2003). We considered amphibians and reptiles together in this chapter as we used the same search methods for both groups.

Spatial Sampling Designs

For all methods except intensive surveys, we surveyed for herpetofauna in non-random sites because our primary goal was detection of the maximum number of species. To assign locations for intensive survey plots, we used ArcView software to divide the monument into 48 4-ha (200 m x 200 m) plots, arranged into eight rows (east-west) and six columns (north-south). We surveyed a randomly selected subset of these plots (Fig. 4.1).

Intensive Surveys

In 2001 and 2002 we conducted searches that were constrained by both time and area to provide the most standardized survey method possible. These were visual encounter surveys (Crump and Scott 1994), limited in duration (1.5 hours) and area (4 ha).

Table 4.1. Amphibian and reptile survey effort by method, Casa Grande Ruins NM, 2001 and 2002.

	2001		2002		
Survey type	# Survey units[a]	Survey hours	# Survey units[a]	Survey hours	Total survey hours
Intensive survey - morning	24	36.0	6	9.0	44.8
Intensive survey - evening	5	2.5	0	0	2.5
Extensive survey - evening [b]	18	47.3	3	5.5	52.9
Pitfall trap array	18	234.5	7	80.2	314.7
Road cruising	1	0.6	1	0.7	1.3

[a] Number of plots for intensive surveys, survey routes for extensive surveys, road cruising, or trapping sessions for pitfall array. See text for number of visits.

[b] Extensive surveys were in the evening (including crepuscular period) only.

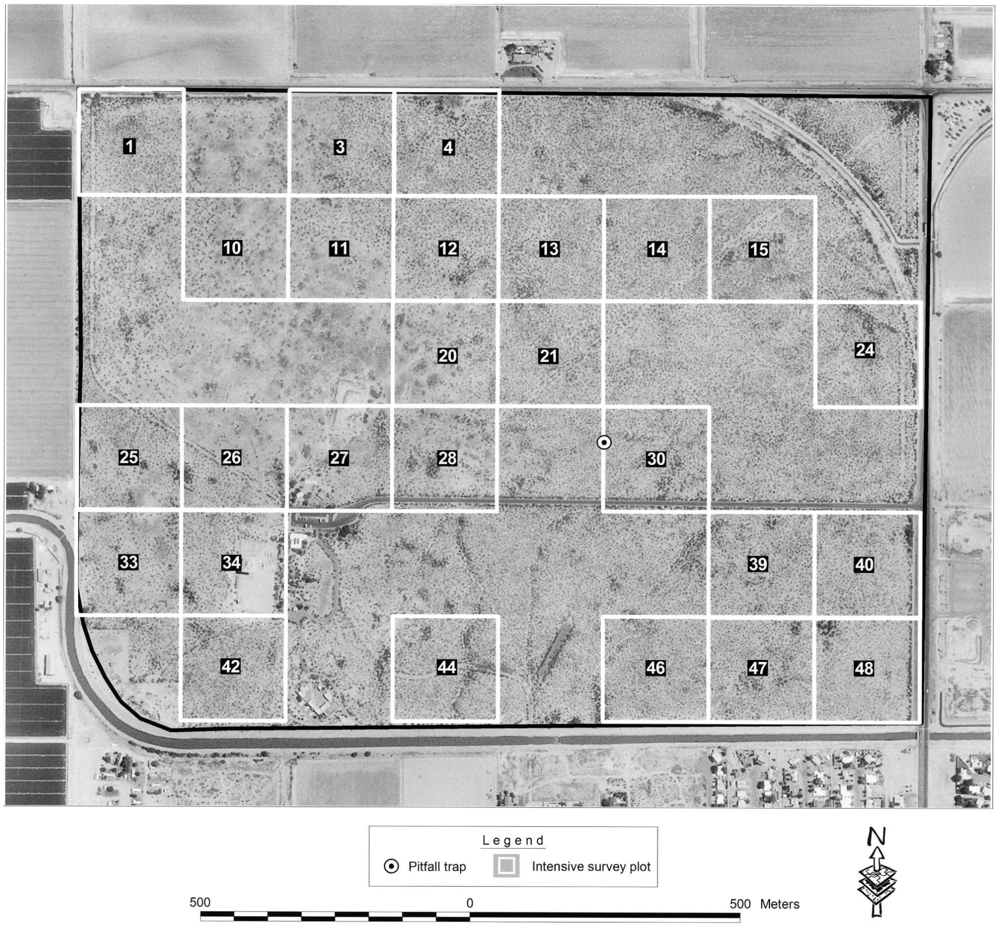

Figure 4.1. Location of intensive survey plots and pitfall trap array for amphibians and reptiles, Casa Grande Ruins NM, 2001 and 2002. See Appendix H for UTM coordinates.

<u>Field Methods</u>

We navigated to the predetermined plot corners (Appendix H) using Garmin eMap GPS units. Vegetation and soil characteristics of the area were then described. Before and after each survey we recorded weather information: temperature (º C), relative humidity (%), cloud cover (%), and wind speed (km/h). During surveys we used Garmin eMap GPS units to ensure that we stayed within the plot and each survey was systematic and non-overlapping so that animals were not counted more than once. At each detection we recorded species, sex, and age class (adult or juvenile)(if known). We finished morning surveys between 9:00 A.M. and 12:30 P.M. during the spring (April and May), and between 8:00 and 10:00 A.M. in the summer (July and August) because lizard activity declined with higher temperatures later in the day. Evening surveys were initiated between 6:30 and 7:30 P.M.

Effort

In April and May 2001 we completed morning visits to 17 plots, and we returned in August to complete six morning visits and five evening visits. We completed an additional six morning visits in July 2002. In total, we visited: 18 plots once each in the morning, three plots once each in the morning and evening, two plots twice in the morning, and two plots twice in the morning and once in the evening. Each survey was completed by a single observer. For this report we express effort as number of surveys because all surveys were for the same length of time.

Analysis

We calculated relative abundance as the mean number of individuals detected per survey across all surveys. We calculated species richness as the number of species observed in each year, across all surveys.

Extensive Surveys

Extensive surveys, a type of visual-encounter survey (Crump and Scott 1994), differed from intensive surveys in that they were not constrained by area or time. We used extensive surveys to search areas that were larger than intensive survey plots, and to provide the flexibility to spend a variable amount of time searching areas of interest (e.g., shallow depressions that may form temporary pools after rains). We completed these surveys during the cooler evening and nighttime periods to maximize our chances of encountering snakes and amphibians that would be active during these times (Ivanyi et al. 2000).

Field Methods

These surveys began after 5:00 P.M., typically including the crepuscular period. Search times for each extensive survey varied from approximately 15 minutes to five hours (mean = 2.4 hours, SD = 1.4) depending on conditions and logistical constraints. Before and after each survey we recorded weather information: temperature (° C), relative humidity (%), cloud cover (%), wind speed (km/h), and an overall description of the conditions. For each animal observed, we recorded species, and sex, and age class (if known). During surveys we periodically recorded UTM coordinates (using Garmin eMap units) to define the boundaries of our search area or the path that we followed.

Effort

We spent 53 hours on 22 extensive surveys in April and August 2001, and in July 2002 (Table 4.1). All but two surveys were completed by a single observer; on these two surveys an inexperienced volunteer accompanied the crew member. Units of effort represent hours of surveying, all but two surveys of which were person-hours.

Analysis

We calculated relative abundance as the mean number of individuals detected per person-hour across all surveys. We calculated species richness as the number of species observed in each year, across all surveys.

Pitfall Trap Array

Pitfall traps are a live-trap, passive sampling technique useful in detecting species that would be difficult to observe because of rarity, limited activity periods, or inconspicuous behavior (Corn 1994).

Field Methods

We constructed a pitfall trap array by placing three 19-L buckets roughly 8 m away and at angles of approximately 120 degrees each from a central bucket (Fig. 4.2; Gibbons and Semlitsch 1981). We dug shallow trenches between buckets in which we placed drift fences (7.6-m long, 0.5-m tall aluminum flashing supported with rebar) that connected each of the three outside buckets to the central bucket. Buckets were buried so that the lip was at ground level. We placed cover boards (50 x 50 cm pieces of plywood) over the buckets to keep the animals cool during the day, minimize mortality, and attract additional animals (Corn 1994).

In an attempt to capture large snakes and other animals that are able to escape from pitfall trap buckets (Corn 1994), we placed one wire-mesh funnel trap (tubes with inwardly-directed cones at each end) at the midpoint along each side of the drift fences (total of six funnel traps). Animals entering via the funnels would fall to the bottom of the tube and be unable to escape. We typically opened the pitfall and funnel traps around sunset, then checked and closed the traps the next morning. For each animal captured, we recorded species, sex, and age class (if known).

Effort

We established one pitfall trap array (with four pitfall traps and six funnel traps) north of the entrance road (Fig. 4.1). We operated the array for a total of 315 hours from July to September 2001, and in July 2002 (Table 4.1).

Analysis

We report the number of animals captured per 100 hours of pitfall array operation.

Road Cruising

Driving slowly on roads at night is recognized as an excellent method for surveying some groups of reptiles, particularly nocturnal snakes (e.g., Rosen and Lowe 1994). Before and after each survey we recorded weather information: temperature (º C), relative humidity (%), cloud cover (%), and wind speed (km/h). For each amphibian and reptile observed, we recorded species, sex and age class (if known), the mileage from the start point of the survey, and whether the animal was alive or dead. We surveyed the entrance road and dirt roads along the south and west monument boundaries with this method.

A B

Figure 4.2. Photos of pitfall trap array showing 19-L bucket (A) at the center of three 8-m-long sheets of aluminum flashing (B) (photos of array at Tumacácori National Historical Park by David Prival).

Effort

We completed two surveys (one each year) totaling 1.3 hours of effort (Table 4.1).

Analysis

We report the number of animals seen during both surveys.

Coverboards

To increase the odds of finding animals, we placed 10 "cover boards" (0.5 x 0.5 m plywood squares which could be used as cover by animals; Fellers and Drost 1994) on both the north- and south-side of the main entrance road, east of the visitor center. We set out the cover boards in April 2001 and collected them at the end of the field season in 2002. We checked underneath cover boards occasionally during extensive surveys.

Incidental Observations

When we encountered amphibians and reptiles outside of formal surveys, we recorded the species, sex and age class (if known), time of observation, UTM coordinates, and route we were following.

RESULTS

We recorded three amphibian and 11 reptile species at Casa Grande Ruins NM (Appendix B). Common side-blotched and western whiptail lizard were the two most abundant species, and together they represented >75% (*n* = 670 of 877) of all detections across all survey methods (Tables 4.2–4.4).

Intensive Surveys

We recorded seven species of reptiles during intensive surveys (Table 4.2). The common side-blotched and western whiptail lizards were the most abundant diurnal lizards in both years, and the common side-blotched was the only lizard recorded on nocturnal intensive surveys. We encountered few snakes during these surveys (3 species), and only the gopher snake was recorded on more than one occasion (Table 4.2). We did not record any amphibians during intensive surveys.

Table 4.2. Total number of observations (*n*) and relative abundance (mean and SE) of reptiles[a] recorded during intensive surveys, Casa Grande Ruins NM, 2001 and 2002. See Appendix B for scientific names.

		2001				2002	
		Morning		Evening		Evening	
Common name	*n*	Mean	SE	Mean	SE	Mean	SE
desert spiny lizard	5	0.1	0.07			0.3	0.33
common side-blotched lizard	252	8.6	1.51	0.4	0.24	8.7	2.69
long-tailed brush lizard	19	0.7	0.20			0.5	0.50
western (tiger) whiptail	330	7.7	1.52			25.3	6.01
gopher snake	2	<0.1	0.06				
long-nosed snake	1			0.2	0.20		
Mohave rattlesnake	1	<0.1	0.04				
unknown snake	1	<0.1	0.04			0.2	0.17
unknown lizard[b]	59	2.2	0.45			1.5	0.76
Species richness	**7**	**6**		**2**		**4**	
Total no. detections	**671**	**449**		**3**		**219**	

[a] No amphibians were recorded on intensive surveys.

[b] Glimpsed before identification could be made.

Extensive Surveys

During extensive surveys we recorded 13 species, which included all but one of the species (Great Plains toad, detected during road cruising) that we detected with all methods combined (Tables 4.2–4.4). The western banded gecko and the common side-blotched lizard were the most abundant reptile species found during extensive surveys, though the long-nosed snake was similarly abundant in 2001 (Table 4.3). We recorded more Couch's spadefoot toads than any other species in 2002, though this was clearly associated with monsoon rains; all but one of the Couch's spadefoot toads were recorded during one post-rain survey in July.

Road Cruising, Pitfall Array, Incidental Observations, and Coverboards

We added one new species to the monument list with the road cruising method (Great Plains toad; Tables 4.2–4.4); in fact we observed all three of the amphibian species recorded by our inventory during one night of road cruising in 2002. Although the pitfall array did not contribute additional species to our monument list, results from the array were consistent with other methods and suggest that common side-blotched and western whiptails are among the most common lizards at the monument (Table 4.4). Incidental detections did not add any species to our lists, but this method did add records for species that were seldom detected by other methods, notably Couch's spadefoot, coachwhip, and common kingsnake. We found no animals underneath coverboards.

Table 4.3. Total number of observations (*n*) and relative abundance (mean and SE) of reptiles and amphibians recorded during extensive surveys, Casa Grande Ruins NM, 2001 and 2002. See Appendix B for scientific names.

			2001		2002	
Group	Common name	*n*	Mean	SE	Mean	SE
Amphibian	Couch's spadefoot	30			10.0	4.73
	Sonoran desert toad	14	0.6	0.25	1.0	0.58
Reptile	western banded gecko	22	1.0	0.52	1.0	0.58
	desert spiny lizard	4	0.2	0.12	0.3	0.33
	common side-blotched lizard	57	2.7	1.70	2.0	2.00
	long-tailed brush lizard	2	0.1	0.11		
	western whiptail	14	0.7	0.44		
	coachwhip	2			0.7	0.67
	gopher snake	2	<0.1	0.05	0.3	0.33
	common kingsnake	1	<0.1	0.05		
	long-nosed snake	21	1.0	0.24	0.7	0.67
	western diamond-backed rattlesnake	1	<0.1	0.05		
	Mohave rattlesnake	4	0.2	0.09	0.3	0.33
	unknown lizard	4	0.1	0.11	0.7	0.67
Species richness		**(178)**	**11**		**10**	

Table 4.4. Total number of observations (*n*) and number of animals captured per 100 hours of pitfall trap array operation, number of individuals observed during road cruising surveys, and number of incidental observations, Casa Grande Ruins NM, 2001 and 2002. See Appendix B for scientific names.

		Pitfall array			Road cruising [b]		Incidental observations	
Group	Common name	*n*	2001	2002	2001	2002	2001	2002
Amphibian	Couch's spadefoot					4		9
	Sonoran desert toad					1	2	19
	Great Plains toad					2		
Reptile	western banded gecko	4	0.4	3.7			2	2
	desert spiny lizard						5	3
	common side-blotched lizard[a]	8	2.6	2.5		1	26	54
	long-tailed brush lizard	2	0.9				2	7
	western (tiger) whiptail	8	3.4				42	81
	coachwhip						1	1
	common kingsnake							2
	long-nosed snake[a]	1	0.4				1	
	Mohave rattlesnake							5
Species richness			**5**	**2**	**0**	**4**	**8**	**10**

[a] One or more individuals captured in funnel traps at pitfall array.
[b] No animals recorded during road cruising in 2001.

INVENTORY COMPLETENESS

It is seems unlikely that we missed several conspicuous species that we would expect to find at the monument: zebra-tailed lizard, desert iguana[3], long-nosed leopard lizard, and sidewinder. Rosen (Appendix N) attributes the lack of recent records for these species to habitat fragmentation and altered vegetation. Species likely present in the monument that we did not detect include snakes that are nocturnal and inconspicuous (and in some cases, fossorial) such as: western blind snake, spotted leaf-nosed snake, saddled leaf-nosed snake, glossy snake, western ground snake, western shovel-nosed snake, and night snake (Appendix E, N; Stebbins 2003). We received an unconfirmed report of a western shovel-nosed snake (Karen Monroe, *pers. com.*). This highlights that confirming the potential presence of these inconspicuous species may require substantial field effort by experienced personnel or documentation (voucher by collection or photograph) by other observers.

We believe that our inventory detected less than 90% of the amphibians and reptiles present simply because reaching this goal would only require finding one more amphibian or two more reptile species. A species accumulation curve for intensive and extensive surveys appears to show that the number of new species reaches an asymptote after our 56 surveys (Fig. 4.3), and indicates that we recorded most of the species likely to be observed with these methods, at least under the environmental conditions (e.g., below-average precipitation) during our study. Note also the dominance of the most common species at the monument; >60% of the species (n = 8 of 13 species) that we recorded with these surveys were detected within the first five surveys[4] and only one new species was detected in the last 26 surveys (Fig. 4.3).

[3] This species is active during hot days and if it was at the monument, should have been found by Charles Conner during his lizard surveys.
[4] See Chapter 1; note that surveys are not plotted in chronological order.

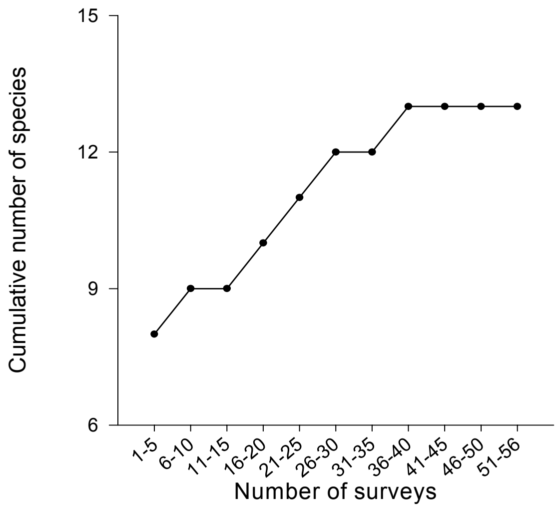

Figure 4.3. Species accumulation curve for intensive and extensive amphibian and reptile surveys, Case Grande Ruins NM, 2001 and 2002. Survey order was randomized to account for differences in animal activity patterns.

DISCUSSION

The amphibian and reptile communities at Casa Grande Ruins NM comprise relatively few species in comparison to what was likely present historically (Appendix N) or in comparison to what has been documented in the course of other recent herpetofauna inventories in management units of similar size in southern Arizona (e.g., Rosen and Mauz 2001, Powell et al. 2002, Powell et al. 2003, Powell et al. 2004). This low species richness likely results from the land uses in the vicinity of the monument (see Chapter 2) and degradation of the nearby Gila River (i.e., loss of aquatic and riparian resources; McNamee 1994, Ingram 2000).

The common side-blotched lizard and western whiptail lizard were the most abundant species we detected in the monument (Tables 4.2–4.4), though the number of animals and species recorded appears to differ with activity period. This pattern is most evident in the results from intensive surveys, which are the most appropriate method for inferring abundance due to their random placement. Observations of western whiptail and common side-blotched lizards decreased in the cooler evening and nighttime periods while observations of western banded geckos increased, a pattern that is consistent with the known behavioral characteristics of these species (Ivanyi et al. 2000, Stebbins 2003). Several species of snakes and toads contribute to a nocturnally active community that is more diverse than the diurnally active community (Tables 4.2–4.4). Although our primary active survey methods for diurnal species (intensive surveys) and nocturnal species (extensive surveys) are not directly comparable because of differences in methodology, the general patterns we observed were substantiated by results from other methods (pitfalls, road cruising, and nocturnal intensive surveys) and life-history characteristics.

Species observed in this study would be expected to occur on the monument due to the environmental characteristics present in the area. Lizards in this area are associated with creosote flats and/or sparse vegetation, and the snakes are primarily generalists (Ivanyi et al. 2000, Stebbins 2003). The common lizards, in particular, are characteristic of the Lower Colorado Valley, while the generalist snakes represent those found abundantly in both the Lower Colorado Valley and Arizona Upland (Mohave rattlesnake and gopher snake) and those that are generally more abundant in the Arizona Upland province of the Sonoran Desert (long-nosed snake and western diamond-backed rattlesnake); however, characteristic Lower Colorado Valley forms, such as the western shovel-nosed snake, spotted night snake, and sidewinder were not observed (Appendix N).

Historically, the area around the monument was biologically diverse because it is situated at the edge of the Lower Colorado Valley province in the mesic transition towards Arizona Uplands, with the Gila River (and pre-historic network of canals) nearby (Appendix N). Over the last century, however, this area has undergone dramatic change including elimination of perennial flow in the adjacent Gila River; associated cienegas and riparian vegetation have disappeared as a result (McNamee 1994, Ingram 2000). Other changes include agriculture, urban development, and road construction, and associated effects (see Chapter 2).

In a review of specimen records from the lowland desert flats around Casa Grande Ruins NM (roughly bounded by the communities of Maricopa, Queen Creek, Florence Junction, Florence, and Casa Grande), Rosen lists 40 species that have been documented and an additional ten species are possible in the area (Appendix E). Rosen (2004) suggested that (1) because many of these species are associated with riparian conditions, they may have been extirpated when the Gila River flows were reduced and (2) additional species associated with Arizona Uplands (saddled leaf-nosed snake, variable sand snake, southwestern black-headed snake, regal horned lizard, and ornate tree lizard) were likely present in the area of Casa Grande Ruins NM, primarily due to proximity of Arizona Uplands, and so may also have been extirpated from the area. While species that are associated with riparian areas are not likely remaining in the monument, it should be noted that the current system of irrigation canals adjacent to the monument might provide connectivity with surrounding areas. Although the canal water moves too quickly to support most aquatic species (e.g., Sonoran mud turtle), some large snakes (e.g., western diamond-backed rattlesnake) are known to swim (Degenhardt et al. 1996) and may use the canals to move across the landscape. In the absence of this "corridor" these species might not persist (or might be less abundant) in the monument. In Phoenix and near Picacho, Sonoran mud turtles, ranid frogs, and checkered garter snakes are known to use irrigation and other canals. In relatively small xeroriparian patches associated with major canals in Florence, the banded sand snake, southwestern black-headed snake, and tree lizard were all abundant at least into the mid-1990s, and probably still persist today (Rosen, *pers. com.*).

Notes on Venomous Reptiles

It should be noted that although we recorded two species of poisonous snake at Casa Grande Ruins NM (for the total of six rattlesnake observations, many of which may have been the same individuals), these were the result of over 100 hours of searching by trained herpetologists. Therefore, these snakes are sufficiently rare to pose a limited threat to visitors. Furthermore, the majority of reptile bites reported to Tucson's Arizona Poison and Drug Information Center were provoked by the victim (e.g., harassment or attempt to handle) and even then, chances of death following a reptile bite are less than one percent (APDIC 2003).

CHAPTER 5: BIRD INVENTORY

PREVIOUS RESEARCH

To our knowledge no bird research has taken place at Casa Grande Ruins NM since a limited-scope banding study in the 1930s (Fast 1936). Barry (1987) created a checklist for the monument, but no source material exists and so we do not consider it here. There are two Breeding Bird Survey routes located approximately 5 and 10 km west of the monument (Sauer et al. 2004): "Cactus Forest" was surveyed in 1991, 1993, and 1996–2002; "Coolidge" transect was surveyed from 1974 to 1985. We found no records of specimens collected from the monument (Appendix L).

METHODS

We surveyed for birds at Casa Grande Ruins NM in 2001 and 2002. We used four field methods: variable circular-plot counts for diurnal breeding birds, nocturnal surveys for owls and nightjars, line transects for winter birds, and incidental observations for all birds in all seasons. Although winter bird surveys were not included in the original study proposal (Davis and Halvorson 2000), we felt they were important in our effort to inventory birds at the monument because many species that use the area during the fall and winter may not be present during spring and summer (breeding season) surveys. We concentrated our primary survey effort on the breeding season because bird distribution is relatively uniform at this time (due to territoriality among most landbird species; Bibby et al. 2002), which increased our precision in estimating relative abundance and also enabled us to document breeding activity. Our survey period included peak spring migration times for most species, which added many migratory species to our list.

We also sampled vegetation around breeding-season survey stations. Vegetation structure and plant species composition are important predictors of bird species richness or the presence of particular species (MacArthur and MacArthur 1961, Rice et al. 1984, Strong and Bock 1990, Powell and Steidl 2000).

Spatial Sampling Designs

We subjectively located all survey stations and transect sections, but because of the monument's small size and relatively homogenous vegetation, our sampling achieved nearly complete coverage of the monument (Fig. 5.1).

Diurnal Surveys: Breeding Season

Field Methods

We used the variable circular-plot method to survey for diurnally active birds during the breeding season (VCP; Reynolds et al. 1980, Buckland et al. 2001). Conceptually, these surveys are similar to traditional "point counts" (Ralph et. al 1995) during which an observer spends a standardized length of time at one location (i.e., station) and records all birds seen or heard and the distance to each bird or group of birds.

We established one transect in 2001 that consisted of 12 stations, but reduced the number of stations to eight in 2002 because of the difficulty in surveying 12 stations in a single morning. Stations along each transect were located a minimum of 250 m apart to maintain statistical independence among observations at each station. Each year we surveyed from mid April through mid June, the period of peak breeding activity for most species in southern Arizona. We visited each station at least four times per season. On each visit we alternated observers and the order in which we surveyed stations (along a transect) to minimize bias by observer, time of day, and direction of travel. We began bird surveys approximately 30 minutes before sunrise and concluded no later than four hours after sunrise,

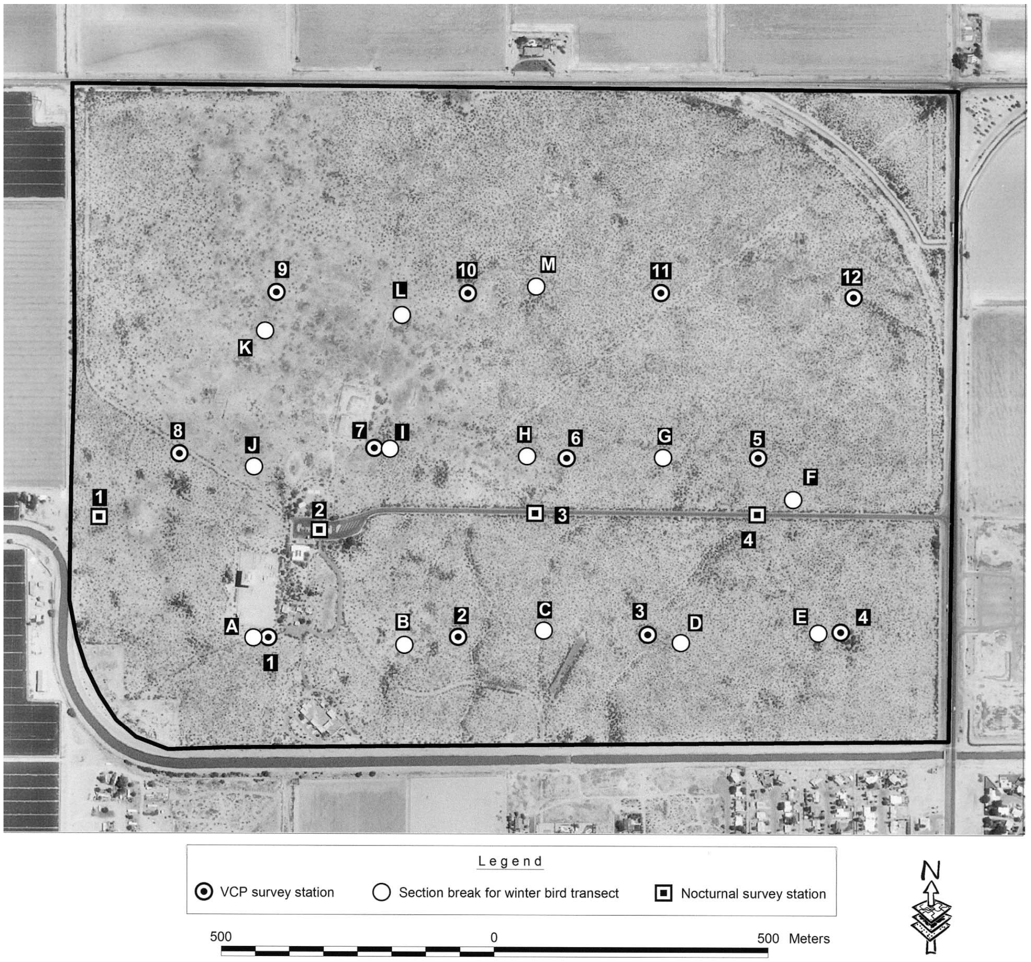

Figure 5.1. Location of bird survey stations (breeding season) and transect sections (non-breeding season) for birds, Casa Grande Ruins NM, 2001 and 2002. See Appendix I for UTM coordinates.

or when bird activity decreased markedly. We did not survey when wind exceeded 15 km/h or when precipitation exceeded an intermittent drizzle.

We recorded a number of environmental variables at the beginning of each transect: wind speed (Beaufort scale), presence and severity of rain (qualitative assessment), air temperature (ºF), relative humidity (%), and cloud cover (%). After arriving at a station, we waited one minute before beginning the count to allow birds to resume their normal activities. We identified to species all birds seen or heard during an eight-minute "active" period. For each detection we recorded distance in meters from the observer (measured with laser range finder when possible), time of detection (measured in one-minute intervals beginning at the start of the active period), and the sex and/or age class (adult or juvenile), if known. We did not measure distances to birds that were flying overhead nor did we use techniques to attract birds (e.g., "pishing"). We made an effort to avoid double-counting individuals that had been recorded at previous stations. If we observed a species during the "passive" count period (between the eight-minute counts), which had not been recorded previously at a station on that visit, we recorded its distance to the nearest station.

Effort

We visited all 12 survey stations four times each in 2001. In 2002 we reduced the number of stations to 8 (station numbers 1, 2, and 6–11) and surveyed each of them four times. Each station was visited for 8 minutes.

Analyses

We calculated relative abundance of each species as the number of detections at all stations and visits (including zero values), divided by effort[5] (total number of visits divided by total number of stations). We reduced our full collection of observations (N = 1,032) to a subset of data (n = 200) that was more appropriate for estimating relative abundance. We used only those detections that occurred ≤ 75 m from count stations (thereby excluding 381 observations) because detectability is influenced by conspicuousness of birds (i.e., loud, large, or colorful species are more detectable than others) and environmental conditions (dense vegetation can reduce likelihood of some detections). Truncating detections may reduce the influence of these factors (Verner and Ritter 1983; for a review of factors influencing detectability see Anderson 2001, Farnsworth et al. 2002). We also excluded observations of birds that were flying over the station (415 observations), birds observed outside of the eight-minute count period (63 observations), and unknown species (18 observations). Some observations met more than one of these criteria for exclusion from analysis.

We include relative abundance estimates for birds seen ≤ 75 m from stations to allow for the most meaningful comparisons among species, and (to some degree) among parks surveyed by this project (see Powell et al. 2004). However, Casa Grande Ruins NM is somewhat unique among Sonoran Desert Network parks in that observers are able to see most birds that are either flying over the monument or are perched (on either the dead mesquite trees or on nearby poles and wires that surround the monument). This unobscured view explains why 40% of the observations were flyovers and 37% of the observations were > 75 m from count stations. Because of the overall low density of birds (reflected in the low number of detections ≤ 75 m from stations), we feel that our estimates of relative abundance convey important information about the birds at each station, but they do not convey sufficient information about the monument's bird community as a whole or put the community in the context of the surrounding landscape. For example, eliminating flyover observations means that we do not report on the hundreds of great-tailed grackles and red-winged blackbirds that fly over the monument en route to adjacent areas.

To account for this bias we calculate *frequency of detections,* which includes birds observed flying over the monument and those at unlimited distances from stations. Relative frequency of detections differs from relative abundance in that it is clearly biased toward those species that are highly visible. Therefore, it can be thought of as an index of the number of birds that we saw and heard at typical stations on the transect (i.e., most similar to an observer's "experience"). Unlike relative abundance, which is an index to population size and thus a valid basis for comparison among species, relative frequency of detection should not be compared among species.

[5] We included visits to stations for which we did not detect birds to accurately estimate our mean and standard error.

To calculate both relative abundance and relative frequency of detection, we grouped data from all stations because of the homogeneity of vegetation in the monument, and used a sample size (n) of 86 in Formula 5.1. Despite some differences among points with regard to the abundance and species detected (Appendix O), there were no stations (or groups of stations) that we felt were notably different to warrant separate analysis (see Powell et al. 2004 for comparison).

Diurnal Surveys: Non-breeding Season

Field Methods

We used a modified line-transect method (Bibby et al. 2002) to survey for birds from October to December 2002. Line transects differ from station transects (such as those used in our breeding-season surveys) in that an observer records birds seen or heard while the observer walks a line, rather than stands at a series of stations. The transect method is more effective during the non-breeding season because bird vocalizations are less conspicuous and frequent, and therefore birds tend to be more difficult to detect (Bibby et al. 2002).

We established one transect at the monument. The transect was broken into sections, with the start and finish points corresponding to the breeding-season stations (Fig. 5.1). Each section was approximately 250 m in length. As with other survey methods, we alternated observers and direction of travel along transects to reduce biases, and did not survey during periods of excessive rain or wind (see breeding-season survey methods for details). We began surveys about 30 minutes after sunrise and continued until we completed the transect. As with breeding-season surveys, we recorded weather conditions at the beginning and end of each survey. Prior to beginning a section, we recorded the section name (e.g., “A–B”) and the start time.

We timed our travel so that we traversed each section in ten minutes, during which time we assigned all birds seen and/or heard into one of the following distance categories: ≤ 100 m, > 100 m, or “flyover.” When possible, we noted the sex and age class of birds. We recorded birds observed before or after surveys as “incidentals” (see section below), and we did not use techniques to attract birds (e.g., “pishing”).

Effort

We visited all 12 sections four times in 2002 (n = 48): 24 October, 8 and 25 November, and 19 December. The total time spent on each section was 10 minutes.

Analysis

Due to the low number of observations (n = 125) within 75 m of the transect lines, we used all observations (n = 173) except unknown species to estimate relative frequency of detections (see Methods section of breeding-season surveys for more details).

Nocturnal Surveys

Field Methods

To survey for owls we broadcasted commercially available vocalizations (Colver et al. 1999) using a compact disc player and broadcaster (Bibby et al. 2002), and recorded other nocturnal species (nighthawks and poorwills) when observed. We established one nocturnal survey transect that bisected the monument along the main entrance road (Fig. 5.1). The transect had four stations that were a minimum of 300 m apart. As with other survey methods, we varied observers and direction of travel along transects and did not survey during periods of excessive rain or wind to reduce bias. We began surveys approximately 45 minutes after sunset.

We began surveys at each station with a three-minute "passive" listening period during which time we broadcast no calls. We then broadcast vocalizations for a series of two-minute "active" periods. We used vocalizations of species that we suspected, based on habitat and range, might be present: elf, western screech, burrowing, and barn owls. We excluded great horned owl from the broadcast sequence because of their aggressive behavior toward other owls. We also did not survey for cactus-ferruginous pygmy owls (*Glaucidium brasilianum cactorum*) at the monument because (1) we believe that habitat does not exist for this species and (2) targeted surveys for threatened or endangered species were not included in the study. We broadcast recordings of owls in sequence from smallest to largest size species so that smaller species would not be inhibited by the "presence" of larger predators or competitors (Fuller and Mosher 1987). During active periods, we broadcasted owl vocalizations for 30 seconds followed by a 30-second listening period. This pattern was repeated two times for each species.

During the count period we used a flashlight to scan nearby vegetation and structures for visual detections. If we observed a bird during the three-minute passive period, we recorded the minute of the passive period in which the bird was first observed, the type of detection (aural, visual or both), and the distance to the bird. If a bird was observed during any of the two-minute active periods, we recorded in which interval(s) it was detected and the type of detection (aural, visual, or both). As with other survey types, we attempted to avoid double-counting individuals recorded at previous stations. We also used multiple observers, alternated direction of travel along transects, and did not survey during inclement weather.

<u>Effort</u>
We visited each of the four nocturnal survey stations three times each in 2001 and twice each in 2002 (n = 20 surveys).

<u>Analysis</u>
We report the total number of detections for both years combined; sample sizes were inadequate for calculating meaningful estimates of relative abundance.

Incidental Observations

<u>Field Methods</u>
When we were not conducting formal surveys and encountered a rare species, a species in an unusual location, or an individual engaged in breeding behavior, we recorded UTM coordinates, time of detection, and (if known) the sex and age class of the bird.

<u>Analysis</u>
We report frequency counts of incidental observations; we cannot calculate relative abundance or frequency of detection (as for breeding- and non-breeding-season surveys) because we did not standardize effort for this survey type.

Breeding Observations

We recorded all breeding observations using the standardized classification system, developed by the North American Ornithological Atlas Committee (NAOAC 1990), which characterizes breeding behavior into one of nine categories: adult carrying nesting material, nest building, adult performing distraction display, used nest, fledged young, occupied nest, adult carrying food, adult feeding young, or adult carrying a fecal sac. We made breeding observations during standardized and incidental surveys.

<u>Analysis</u>
We report frequency counts of breeding observations.

Vegetation Sampling at Diurnal Breeding-Season Stations

We sampled vegetation associated with breeding-season stations. Because of the homogeneity of vegetation at the monument, we sampled vegetation at six of the 12 stations (VCP stations 1, 2, 6, 8, 11, and 12). We sampled vegetation at five subplots located at a modified random direction and distance from each station. Each plot was located within a 72° range of the compass from the station (e.g., Plot 3 was located between 145° and 216°) to reduce clustering of plots. We randomly placed plots within 75 m of the stations to correspond with truncation of data used in estimating relative abundance.

At each plot we used the point-quarter method (Krebs 1998) to sample vegetation by dividing the plot into four quadrants along cardinal directions. We applied this method to plants in three height categories: sub-shrubs (0.5–1.0 m), shrubs (> 1.0–2.0 m), trees (> 2.0 m), and one size category: potential cavity-bearing vegetation (> 20 cm diameter at breast height). If there was no vegetation for a given category within 25 m of the plot center, we indicated this in the species column. For each individual plant, we recorded distance from the plot center, species, height, and maximum canopy diameter (including errant branches). Association of a plant to a quadrant was determined by the location of its trunk, regardless of which quadrant the majority of the plant was in; no plant was recorded in more than one quadrant. Standing dead vegetation was only recorded in the "potential cavity-bearing tree" category. On rare occasions when plots overlapped we repeated the selection process for the second plot.

Within a 5-m radius around the center of each plot, we visually estimated (1) percent ground cover by type (bare ground, litter, or rock); and (2) percent aerial cover of vegetation in each quadrant using three height categories: 0–0.5 m, > 0.5–2.0 m, and > 2.0 m. For both estimates we used one of six categories for percent cover: "0" (0%), "10" (1–20%), "30" (21–40%), "50" (41–60%), "70" (61–80%), and "90" (81–100%).

Analysis

We collected these data to characterize gross vegetation characteristics around some survey stations[6]. In the event that future bird surveys detect marked changes in species or communities, the vegetation data reported in Appendix Q will provide a baseline for measurement and comparison of potential explanatory variables.

RESULTS

We recorded 82 bird species during the two years of the study (Appendix C). Seventy one percent (*n* = 58) of the species that we observed were neotropical migrants. We observed a number of species of conservation concern: loggerhead shrike, burrowing owl, peregrine falcon, and ferruginous hawk, all of which are considered "Species of Concern" by the U.S. Fish and Wildlife Service (see Appendix C for other conservation designations). We recorded three non-native species: rock pigeon, European starling, and house sparrow.

Diurnal Surveys: Breeding Season

We recorded 63 species during diurnal breeding-season surveys at the monument (Appendix C). Of these, we were able to estimate relative abundance for 29 species (Table 5.1). Excluding Brewer's sparrow (for which 80% of observations were from a single day), mourning doves were the most abundant species during this study (Table 5.1). Gambel's quail and house sparrow were also common. By including birds that were seen flying over the monument and those seen or heard at unlimited distances from stations (see methods section), the frequency of detections for each species provides

[6] This effort did not add species to the plant list for the monument.

Table 5.1. Number of observations (sum) and relative abundance of birds recorded within 75 m of count stations during breeding-season surveys, Casa Grande Ruins NM, 2001 and 2002. List excludes flyovers and observations made outside of the eight-minute count period. See Methods section for details on estimation of relative abundance and effort. See Appendix C for scientific names.

		Relative abundance	
Common name	Sum	Mean	SE
Gambel's quail	30	0.35	0.061
American kestrel	1	0.01	0.012
mourning dove	57	0.66	0.080
Inca dove	2	0.02	0.023
burrowing owl	3	0.03	0.020
lesser nighthawk	5	0.06	0.030
black-chinned hummingbird	9	0.10	0.044
Anna's hummingbird	10	0.12	0.035
Costa's hummingbird	2	0.02	0.016
Gila woodpecker	2	0.02	0.016
gilded flicker	4	0.05	0.028
western wood-pewee	1	0.01	0.012
ash-throated flycatcher	5	0.06	0.025
horned lark	13	0.15	0.088
verdin	11	0.13	0.036
cactus wren	5	0.06	0.025
European starling	1	0.01	0.012
yellow warbler	1	0.01	0.012
MacGillivray's warbler	1	0.01	0.012
Wilson's warbler	1	0.01	0.012
western tanager	1	0.01	0.012
chipping sparrow	2	0.02	0.023
Brewer's sparrow	87[a]	1.01	0.474
vesper sparrow	1	0.01	0.012
lark sparrow	2	0.02	0.023
great-tailed grackle	1	0.01	0.012
Bullock's oriole	1	0.01	0.012
house finch	16	0.19	0.056
house sparrow	20	0.23	0.065

[a] Seventy observations were on a single day.

additional information on the bird community at the monument: cliff swallow and mourning dove had the highest number of detections (Table 5.2). Four commonly detected species (most often seen flying over the monument) were rock pigeon, red-winged blackbird, great-tailed grackle, and house finch (Table 5.2).

The most widespread species, based on their presence at all 12 survey stations, were the mourning dove, great-tailed grackle, and house finch (Appendix O). Conversely, 16 species were recorded at only one station. Of the most widespread species, the relative frequency of detections differed most among points for the house finch and least among points for the great-tailed grackle.

Table 5.2. Number (sum) and frequency of detection of all birds seen or heard during eight-minute counts during breeding-season surveys, Casa Grande Ruins NM, 2001 and 2002. List includes all individuals that were identified to species. See Methods section for details on estimation of frequency of detection. See Appendix C for scientific names.

		Frequency of detection	
Common name	Sum	Mean	SE
Gambel's quail	65	0.76	0.057
Swainson's hawk	1	0.01	0.012
red-tailed hawk	1	0.01	0.012
American kestrel	11	0.13	0.049
prairie falcon	2	0.02	0.016
sandhill crane	12	0.14	0.140
killdeer	1	0.01	0.012
black-necked stilt	2	0.02	0.023
rock pigeon	93	1.08	0.704
white-winged dove	19	0.22	0.067
mourning dove	155	1.80	0.136
Inca dove	2	0.02	0.023
burrowing owl	12	0.14	0.038
lesser nighthawk	7	0.08	0.034
black-chinned hummingbird	10	0.12	0.048
Anna's hummingbird	16	0.19	0.045
Costa's hummingbird	2	0.02	0.016
Gila woodpecker	23	0.27	0.051
ladder-backed woodpecker	1	0.01	0.012
gilded flicker	20	0.23	0.071
western wood-pewee	2	0.02	0.016
Say's phoebe	1	0.01	0.012
ash-throated flycatcher	18	0.21	0.044
western kingbird	8	0.09	0.036
loggerhead shrike	4	0.05	0.023
common raven	5	0.06	0.025
horned lark	14	0.16	0.074
cliff swallow	185	2.15	0.988
verdin	15	0.17	0.041
cactus wren	16	0.19	0.042
northern mockingbird	23	0.27	0.048
curve-billed thrasher	1	0.01	0.012
European starling	49	0.57	0.173
American pipit	1	0.01	0.012
yellow warbler	1	0.01	0.012
MacGillivray's warbler	1	0.01	0.012
Wilson's warbler	1	0.01	0.012
western tanager	1	0.01	0.012
chipping sparrow	2	0.02	0.023
Brewer's sparrow	114	1.33	0.497
vesper sparrow	1	0.01	0.012
lark sparrow	2	0.02	0.023
lark bunting	27	0.31	0.222
red-winged blackbird	74	0.86	0.345
great-tailed grackle	59	0.69	0.085
brown-headed cowbird	4	0.05	0.028

		Frequency of detection	
Common name	Sum	Mean	SE
Bullock's oriole	1	0.01	0.012
house finch	92	1.07	0.160
lesser goldfinch	3	0.03	0.026
house sparrow	68	0.79	0.128

There were (qualitatively) significant within-season changes in the bird community across four breeding-season surveys periods (both years combined): 19 species were recorded in all four two-week periods, whereas 32 species were recorded in only one two-week period (the majority during April 15–31; Appendix P). These observations suggest that up to 40% of species recorded during breeding-season surveys were likely migrants, and underscores the importance of the monument to species that might only be present in the area for a brief period of time (for a review of the life history and conservation of neo-tropical migrants, see Rappole [1995]).

Diurnal Surveys: Non-breeding Season

We observed 32 species during four surveys in the fall of 2002 (Table 5.3). Mourning dove and great-tailed grackle were the most frequently detected species (due to the low number of individuals detected on winter surveys we did not truncate detections by distance from point), and we recorded 19 species that were represented by only one or two individuals. We recorded eight species during non-breeding-season surveys that we did not find during breeding-season surveys (Appendix C). The bird community was apparently dominated by a few abundant species during this time period (eight species comprised 85% of all detections) though this may be, to some extent, an artifact of the lower detectability of some species during the non-breeding season (Bibby et al. 2002) or at further distances from the observer.

Nocturnal Surveys

We recorded four species during nocturnal surveys: lesser nighthawk (n = 11 observations), great horned owl (n = 5), burrowing owl (n = 4), and barn owl (n = 2).

Incidental and Breeding Observations

We recorded 57 observations of 36 species outside of formal surveys, including eight observations for species that we did not find with any other survey type (Appendix C). We observed evidence of breeding activity for 11 species, most commonly mourning doves (Table 5.4). One notable observation for Gambel's quail in 2002 included active predation of a nest by a gopher snake.

Vegetation Characteristics

Vegetation was relatively uniform among stations, based on a qualitative assessment of our field data. Creosote dominated the sparse shrub and subshrub layers and a few large mesquite trees provided overstory vegetation structure (Appendix Q). The soil surface was predominately mineral soil.

Table 5.3. Relative frequency of detection of birds recorded during non-breeding season surveys, Casa Grande Ruins NM, 2002. See Methods section for details on estimation of frequency of detection. See Appendix C for scientific names.

		Frequency of detection	
Common name	Sum	Mean	SE
Gambel's quail	1	0.02	0.021
great blue heron	1	0.02	0.021
great egret	1	0.02	0.021
northern harrier	2	0.04	0.030
Cooper's hawk	2	0.04	0.030
red-tailed hawk	2	0.04	0.030
American kestrel	1	0.02	0.021
merlin	1	0.02	0.021
peregrine falcon	1	0.02	0.021
killdeer	1	0.02	0.021
rock pigeon	28	0.60	0.574
mourning dove	89	1.89	0.821
burrowing owl	2	0.04	0.030
black-chinned hummingbird	1	0.02	0.021
Anna's hummingbird	19	0.40	0.099
Costa's hummingbird	2	0.04	0.030
northern flicker	1	0.02	0.021
gilded flicker	10	0.21	0.080
Say's phoebe	6	0.13	0.058
loggerhead shrike	7	0.15	0.052
common raven	2	0.04	0.043
verdin	2	0.04	0.030
rock wren	4	0.09	0.041
blue-gray gnatcatcher	7	0.15	0.080
northern mockingbird	1	0.02	0.021
European starling	1	0.02	0.021
American pipit	2	0.04	0.030
yellow-rumped warbler	26	0.55	0.208
white-crowned sparrow	46	0.98	0.300
great-tailed grackle	75	1.60	0.891
house finch	19	0.40	0.151
house sparrow	4	0.09	0.051

Table 5.4. Number of observations for each breeding behavior for birds, Casa Grande Ruins NM, 2001 and 2002. Breeding behaviors follow standards set by NAOAC (1990). See Appendix C for scientific names.

	Breeding behavior						
Common name	Nest building	Nest with eggs	Nest with young seen or heard	Occupied nest	Adults carrying food	Distraction displays	Recently fledged young
Gambel's quail				1			
mourning dove	1	2		1			
Inca dove	1						
lesser nighthawk		1					1
common poorwill							1
Anna's hummingbird						1	
gilded flicker			1				2
cliff swallow							1
verdin			1		1		
cactus wren				1			
European starling			1		1		

INVENTORY COMPLETENESS

Based on our complete coverage of the monument for two breeding seasons, we believe that we recorded all of the species that permanently resided or bred in the monument. However, a species-accumulation curve (Fig. 5.2) predicts that we would record additional species with further effort. This is particularly true for migrant species. Because of their high mobility, it is not possible to determine exactly how many species of birds might occur at Casa Grande Ruins NM, but we believe that there are 62 species that are likely additions to the monument's species list (Appendix F).

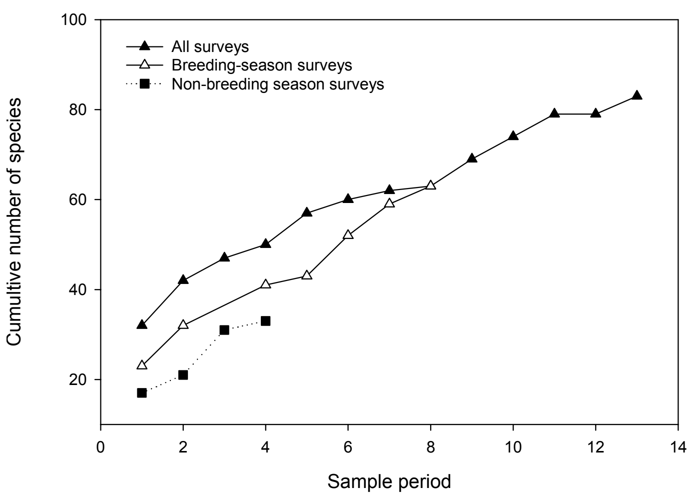

Figure 5.2. Species accumulation curves for detections from all bird surveys combined, Casa Grande Ruins NM, 2001 and 2002. Sample periods for breeding- and non-breeding-season surveys are for one survey day and sample period for "all surveys" is a completely randomized combination of the four survey types, in which each period represents 100 observations. Sample curves for breeding and non-breeding-season surveys are randomized as well.

DISCUSSION

We recorded a surprising number of species of raptors; 10 species of diurnal raptors including all four species of falcons that could occur in the area. Two of the 10 species, ferruginous hawk and peregrine falcon, are “Wildlife of Special Concern” in the state of Arizona (Appendix C). Although we did not investigate habitat use (i.e., identify or quantify resource use of birds), it is possible that these raptors were drawn to the abundant small mammal (i.e., round-tailed ground squirrel) and rabbit populations in the monument, particularly in contrast to the surrounding (primarily urban and agricultural) lands. Despite the high number of species that we detected, the number of detections for regionally rare or uncommon species (e.g., most falcons and migrating warblers) was low and may indicate that there might be just enough habitat to draw in a few individuals, but not enough to entice them to stay for long periods of time (i.e., it is “stopover” habitat). This would be particularly true for wide-ranging species such as raptors.

We recorded nine species of migrating warblers, most of which were only represented by a few individuals (Appendix C). Casa Grande Ruins NM cannot support a large number of migratory birds because of its small size and lack of vegetation structure (see review in Skagen et al. 1998), but as development increases on the lands surrounding the monument, maintaining suitable habitat for species to use briefly during migration may become even more important.

Abundance of Generalist Species

All of the most abundant species at Casa Grande Ruins NM are considered human-adapted generalist species in southern Arizona (i.e., they reach high densities in human-dominated landscapes; Mills et al. 1989, Germaine et al. 1998): mourning dove, rock pigeon, Gila woodpecker, cliff swallow, European starling, red-winged blackbird, great-tailed grackle, house finch, and house sparrow (Tables 5.1–5.3). Rock pigeon, house finch, and house sparrow regularly use the Casa Grande structure and therefore cause damage to the structure through roosting and nesting (Swann et al. 1994, NPS 1997). Although we observed rock pigeon near the Casa Grande during incidental observations, we did not record them during breeding-season surveys at the station near the structure (Station 1, Fig. 5.1; Appendix O). They were probably roosting on the structure, but because the observer was stationary, the birds may not have been visible. European starling are not considered a pest species at the monument, but we recorded them in high numbers around the Casa Grande and on the structure itself (Brian Powell, *pers. obs.*).

Studies of bird communities from Tucson and Phoenix provide a useful comparison for evaluating the potential for the current bird community at Casa Grande Ruins NM. Bird species richness in Phoenix was negatively correlated with a variety of urbanization-related factors that also affect Casa Grande Ruins NM area: bank stabilization, house and road density, and exotic plants (Green and Baker 2003). Most researchers studying urban/suburban bird communities in the southwest stress the importance of maintaining (1) native vegetation in landscaping; and (2) a patchwork of native desert areas (Mills et al. 1989, Germaine et al. 1998). The latter does not exist in the immediate vicinity of the monument, and therefore we would expect the generalist species currently present at the monument to continue dominating the bird community and perhaps increase in abundance.

Burrowing Owls

We found burrowing owls during all survey types, in all seasons (Appendix C), and at breeding-season survey stations throughout the monument (Appendix O). Burrowing owls are considered a Sensitive Species by the Bureau of Land Management (HDMS 2004) and in Arizona only small populations exist in areas dominated by agricultural, urban, and desert areas (Brown and Mannan 2002). Conway and Ellis (2004) completed an extensive survey of burrowing owls in the area in 2003; these researchers found 11 nest sites at the monument and 126 nests in the surrounding area. They also documented higher nest success at the monument (69%) than in surrounding lands (55%); additional research would be needed to determine if these differences are continuous over time. That study underscores a significant strength of single-species surveys: one could not have used data generated from our surveys to estimate density of owl burrows on the monument.

Historical Changes in the Bird Community

Because no quantitatively based studies had taken place prior to ours, it is difficult to place our findings in an historical context. Yet anecdotal information about the plant community at the monument is available, and plant communities are good predictors of bird species richness (MacArthur and MacArthur 1961, Rice et al. 1984, Strong and Bock 1990). Before the drop in the groundwater table and subsequent loss of larger mesquite trees (see Chapter 2), Casa Grande Ruins NM hosted a number of bird species that are no longer found, most notably Crissal thrasher and northern cardinal (Fast 1936). Both of these species require a higher density of trees and shrubs than is currently present at the monument (Cody 1999, Powell and Steidl 2002). It is possible, given the monument's close proximity to the Gila River, that the area once had an extensive forest of large mesquites and a dense shrub layer, similar to what is currently found adjacent to some sections of the Santa Cruz and San Pedro rivers. Species that would nest in these vegetation types include Bell's vireo (*Vireo bellii*), Lucy's warbler, yellow-breasted chat (*Icteria virens*), Abert's towhee (*Pipilo aberti*), and varied bunting (*Passerina versicolor*) (Powell et al. 2004). It is likely that habitat also existed for the cactus ferruginous pygmy owl.

CHAPTER 6: MAMMAL INVENTORY

PREVIOUS AND ONGOING RESEARCH

Karen Monroe, a graduate student at the University of Arizona (School of Natural Resources), is currently (2004) studying the movement patterns and life history of round-tailed ground squirrels (Koprowski and Monroe 2003). Swann et al. (1994) assessed the damage to cultural resources by birds and small mammals. We also located three mammal specimens collected from the monument (Appendix L).

METHODS

We surveyed for mammals using three field methods: trapping for rodents and ground squirrels (primarily nocturnal; herein referred to collectively as small mammals), infrared-triggered photography for medium and large mammals, and incidental observations for all mammals. We did not net for bats because doing so without standing water, which brings in bats, would likely not have been productive (Ronnie Sidner, *pers. com.*).

Spatial Sampling Design

We selectively placed plots in areas of the monument that we felt represented slight variations in vegetation community and structure (N = 8, Fig. 6.1). We avoided the vicinity of the picnic grounds because of the high density of round-tailed ground squirrels in that area and we prioritized the likelihood of documenting additional species in other areas. We subjectively placed infrared-triggered cameras in area of dense cover near animal trails.

Small Mammals

Field Methods

We trapped small mammals once in the spring and twice in the fall of 2002. We used Sherman® live traps (large, folding aluminum or steel, 3 x 3.5 x 9"; H. B. Sherman, Inc., Tallahassee, FL) in grids (White et al. 1983), with 12.5-m or 15-m spacing among traps arranged in configurations of five rows and five columns (eight plots) or 10 rows and five columns (one plot). On one plot (07) we placed five traps in a single row. We opened and baited (one tablespoon: 16 parts dried oatmeal to one part peanut butter) traps in the evening, then checked and closed traps the following morning. We placed a small amount of polyester batting in each trap to prevent trap deaths due to cold nighttime temperatures. We marked each captured animal with a permanent marker to facilitate recognition; these "batch marks" appeared to last for the duration of the sampling period. For each animal we recorded species, sex, age class (adult, subadult, or juvenile), reproductive condition, weight, and measurements for right-hind foot, tail, ear, and head, and body. For males we recorded reproductive condition as either scrotal or non-reproductive; for females we recorded reproductive condition as one or more of the following: non-reproducing, open pubis, closed pubis, enlarged nipples, small or non-present nipples, lactating, post-lactating, or non-lactating.

Effort

We trapped small mammals at eight sites (nine plots). The number of trap nights at each plot ranged from 1 to 3 and the number of traps set each night for each plot was 5 (plot 7), 25 (plots 1–6, and 8), or 50 (plot 9). On one site (number 4) we trapped for only one night because ants were causing trap mortality. We placed two plots (1 and 8) at the same site on the first and last sampling period to quantify inter-seasonal changes in abundance.

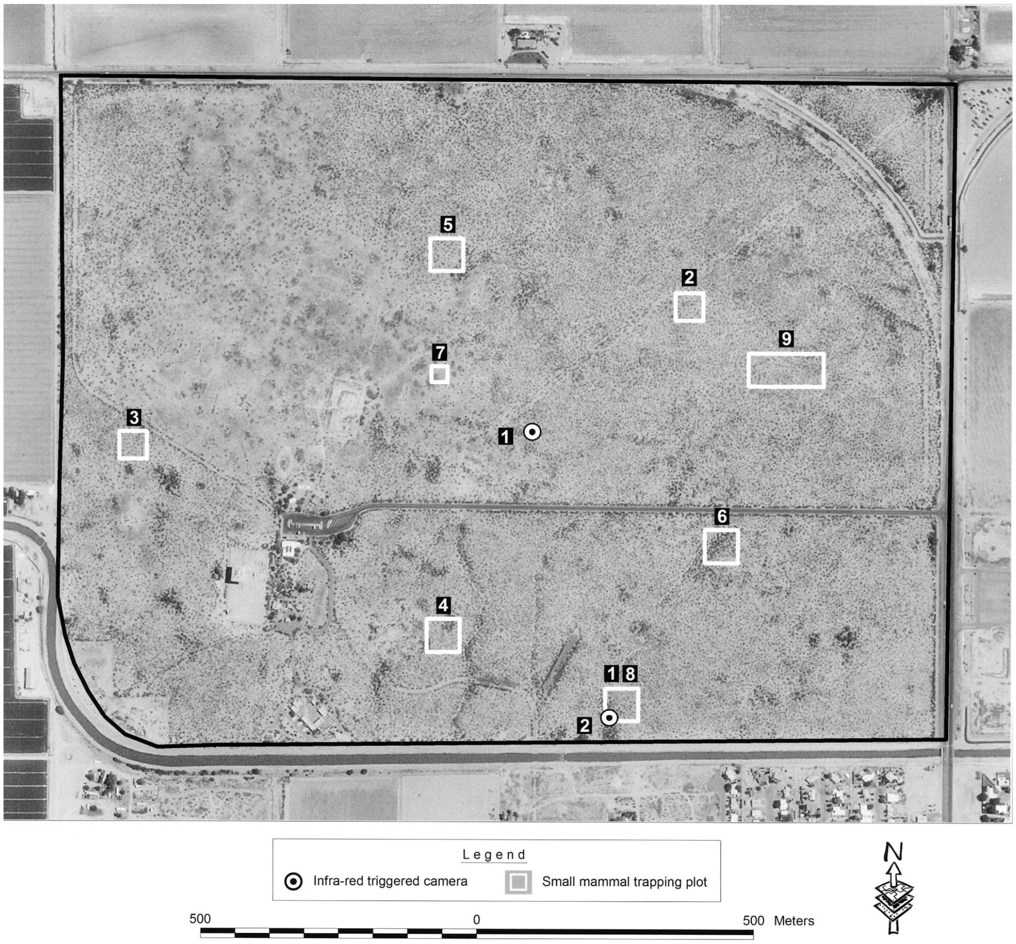

Figure 6.1. Location of small-mammal trapping plots and infrared-triggered cameras at Casa Grande Ruins NM, 2001 and 2002. See Appendix J for plot coordinates.

Analysis

We calculated relative abundance[7] (Formula 6.1) for species by dividing the number of captures by the number of trap nights (number of traps multiplied by number of nights they were open) after accounting for sprung traps (misfired or occupied; Beauvais and Buskirk 1999). Sprung traps reduce trap effort because they are no longer "available" to capture animals; we account for this by multiplying the number of sprung traps by 0.5 (lacking specific information, we estimate sprung traps were available for half of the night; Nelson and Clark 1973).

[7] When interpreting relative abundance, there is an assumption of equal probability of detections among species. Although beyond the scope of this report to quantify those differences, it is important to recognize that individuals of each species react differently to the metal traps. Therefore, aside from species richness estimates, the most meaningful comparisons are intra-specific differences, both within and among sites.

Formula 6.1:
Percent relative abundance =

$$\frac{\textbf{Total number of new captures}}{\textbf{Total number of trap nights – (Number of sprung traps x 0.5)}} \times 100$$

Medium and Large Mammals

Field Methods

We used infrared-triggered cameras (herein referred to as “Trailmaster”; Trailmaster®; model 1500, Goodman and Associates, Inc, Lenexa, KS; Kucera and Barrett 1993) to record the presence of medium and large mammals. Trailmasters have three components: receiver, transmitter, and camera (Fig. 6.2). The transmitter sends an infrared beam to the receiver at a specified rate (5 times per second for this study). The receiver then sends a signal (via cable) to a camera mounted on a tripod 6–8 m away. When an animal blocks the infrared beam the camera takes a picture.

We set the receiver and transmitter approximately 8 m apart and 20 cm above the ground so that medium and large mammals were captured on film but smaller animals such as rodents and birds were not. We set cameras to take no more than one photograph every five minutes to reduce the chances of recording the same individual more than once (on the same occasion). We placed cameras in two areas of the monument (Fig. 6.1; UTM coordinates = 450293/3651045, and 450436/3650530) that we thought would record the highest number of species; typically these were in areas of dense vegetation. We baited camera sites with a commercial scent lure (ingredients included synthetic catnip oil, bobcat musk, beaver castorium, and propylene glycol as a preservative) or canned cat food. We checked cameras approximately every two weeks to change film and batteries and to ensure their proper function. We photographed a placard documenting the date and camera location on the first exposure of every new roll of film.

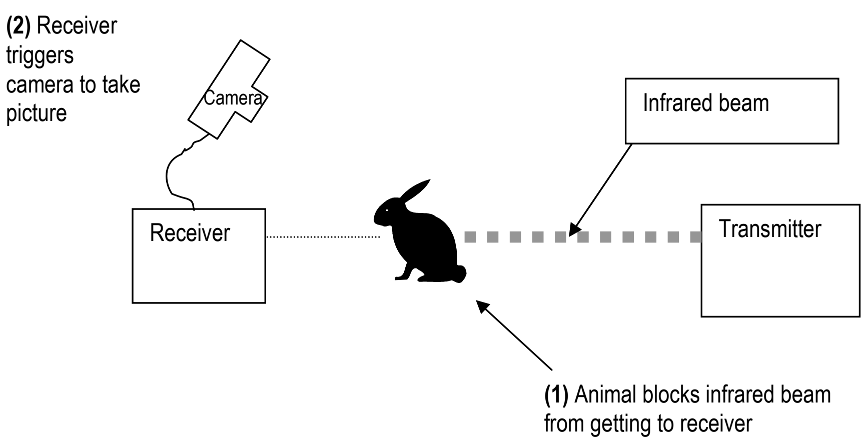

Figure 6.2. Diagram of infrared-triggered camera (Trailmaster) set-up. Image based on Swann et al. (2004).

Effort

We operated Trailmaster cameras in the spring and summer of 2002 for a total of 134 days.

Analysis

Trailmaster cameras are the most cost-effective method for recording the presence of medium and large mammal species (Kucera and Barrett 1993, Cutler and Swann 1999). However, one drawback to this method is an inability to differentiate individuals, which precludes any estimates of abundance (i.e., one must be able to determine whether one animal has been photographed repeatedly or whether more than one individual has been photographed). In some cases, size or physical abnormality may differentiate individuals of any species, but this was not evident in our photographs. Also, each species is more or less likely to be attracted to the camera area. Therefore, we report the number of times a species was photographed to indicate species that *may* be common, based on the number of photographs.

Incidental Observations and Sign

As with other taxa, we recorded UTM coordinates of mammal sightings made outside of formal surveys. Observers from all field crews (e.g., bird crew) recorded mammal sightings. Because of the low number of observations by our crews, we also report observations by monument staff. Finally, we repeatedly checked the Casa Grande and roof structure for bats.

RESULTS

Small Mammals

Excluding recaptures, we trapped 154 individuals representing 7 species on a total of 470 trap nights (Table 6.1). The number of species trapped at sites ranged from 2 to 6 species (mean = 3.4 ± 0.48). After accounting for differences in trapping effort among sites, Merriam's kangaroo rat was the most widespread and abundant, though the Sonoran Desert pocket mouse was found on all but one grid and was almost as abundant. Combined relative abundance of the other five species was 18% of that for both Merriam's kangaroo rat and Sonoran Desert pocket mouse combined.

We placed two plots in the same location (plots 1 and 8; Fig. 6.1) for the first and last sampling periods (April and December, respectively), and we observed considerable differences in the structure of the small-mammal community between those sampling events. Species richness changed from 6 to 2 species, the number of individuals trapped increased from 11 to 19, and Merriam's kangaroo rat was the only species trapped in both sampling periods (Table 6.1).

Medium and Large Mammals

Trailmaster cameras took 30 photographs of animals. The most photographed species was the cottontail (Table 6.2). These animals were most likely desert cottontails; eastern cottontail (*Sylvilagus floridanus*) is difficult to differentiate in photographs, but is unlikely to be present in the area near the monument (Hoffmeister 1986). Cameras took 10 photographs of black-tailed jackrabbits and one photograph each of Gambel's quail, greater roadrunner, and western white-throated woodrat.

Table 6.1. Total number of small mammals trapped (n) and percent relative abundance (PRA), excluding recaptures, Casa Grande Ruins NM, 2002. See Formula 6.1 for PRA formula. See Appendix D for scientific names.

	Plot									
	1		2		3		4		5	
Common name	*n*	PRA	*n*	PRA	*n*	PRA	*n*	PRA	*n*	PRA
round-tailed ground squirrel	2	4.7							1	2.0
Arizona pocket mouse	1	2.3	2	4.7			2	12.1	4	8.1
Sonoran Desert pocket mouse	2	4.7	2	4.7	8	21.9	8	48.5	12	24.2
Merriam's kangaroo rat	3	7.0	5	11.6	1	2.7	1	6.1	11	22.2
deer mouse	2	4.7	2	4.7						
southern grasshopper mouse	1	2.3								
western white-throated woodrat										
Total number of traps set	50		50		50		25		75	
Number of sprung traps	14		14		27		17		51	

	Plot								All plots	
	6		7		8		9			
Common name	*n*	PRA	*n*	PRA	*n*	PRA	*n*	PRA	***n***	**Average PRA**
round-tailed ground squirrel	2	4.4							5	1.5
Arizona pocket mouse	1	2.2							10	2.9
Sonoran Desert pocket mouse	19	42.2	3	100.0			1	1.4	55	16.0
Merriam's kangaroo rat	9	20.0	1	33.3	17	48.6	27	37.2	75	21.8
deer mouse							1	1.4	5	1.5
southern grasshopper mouse					2	5.7			3	0.9
western white-throated woodrat	1	2.2							1	0.3
Total number of traps set	75		5		50		100			
Number of sprung traps	60		4		30		55			

Table 6.2. Results of Trailmaster camera, incidental collection of sign, and incidental observations by University of Arizona inventory personnel and monument staff, Casa Grande Ruins NM.

		Detection type			
Group	Common name	Trailmaster photo	Sign (bones)	Incidental observation by UA personnel	Incidental observations by others
Bird	Gambel's quail	1			
	greater roadrunner	1			
Mammal	American badger		1		
	domestic dog			2	
	coyote				1 (Karen Monroe)
	striped skunk			1	
	feral cat		1		X[a]
	round-tailed ground squirrel			3	
	cliff chipmunk				1[b]
	desert cottontail	17		3	
	black-tailed jackrabbit	10		6	

[a] Seen regularly by monument personnel (Jolene Johnson, *pers. com*. to Brian Powell).
[b] Seen for approximately one week (in April 2002) by monument personnel at the visitor center (*pers. com.* to Brian Powell).

Incidental Observation and Sign

University of Arizona personnel made incidental observations of 5 species during the course of the study (Table 6.2). Monument personnel reported regular observation of feral cats and a single observation of a cliff chipmunk. We did not observe bats in the Casa Grande or supporting roof structure.

Voucher Specimens and Photographs

We took 17 voucher specimens during the course of small-mammal trapping at the monument (Appendix M) and collected two skulls, one each of domestic cat and American badger (Table 6.2).

INVENTORY COMPLETENESS

Small Mammals

The majority of our mammal survey effort targeted small mammals. Based on a species accumulation curve, it appears that we trapped most of the species that occurred on the monument during the time of the study (Fig. 6.3). A comparison of our effort to that of Powell et al. (2004) at Tumacácori National Historical Park reveals that after 6 sampling periods the number of new species being found decreases significantly, though new species can still be found (Fig. 6.3). For Casa Grande Ruins NM, a number of species could be present or may historically have been present at the monument, based on range maps and published habitat associations, including: little pocket mouse, Bailey's pocket mouse, cactus mouse, Arizona cotton rat, and the non-native house mouse (Hoffmeister 1986; Appendix G). It is quite likely that these species, particularly cactus mouse[8] and house mouse, would be captured with additional survey effort. Also, there are a few species that are within range but would require higher density of vegetation (particularly dense grasses and forbs): Botta's pocket gopher, silky pocket mouse, banner-tailed kangaroo rat, western harvest mouse, and hispid cotton rat (Hoffmeister 1986). Based on the description of the vegetation at the monument prior to cattle grazing and mesquite die-off (Clemensen 1992), it is likely that these species were once common residents of the monument. Also, Merriam's mouse, probably once common at the monument before the die-off of the large mesquite forest, is very restricted to that vegetation component and therefore unlikely to be present now. Finally, there is a group of species within range but preferring rockier substrates, as their names imply, (cliff chipmunk, rock squirrel, and rock pocket mouse), that may have used the monument during dispersal. The report of the cliff chipmunk (Table 6.2) should be considered a tentative identification.

Medium and Large Mammals

Our Trailmaster survey effort was insufficient to document the medium and large mammals at the monument, despite having operated the cameras for 134 days. However, based on incidental observations by our survey crews and by monument staff, it appears that the species list of medium and large mammals that regularly use the monument is small: house cat, stripped skunk, domestic dog, and coyote (Table 6.2, Appendices D, G). Because of close proximity to the Gila River and the natural areas to the north of the river, a host of other species may occasionally be present at the monument: raccoon, hooded and white-backed hog-nosed skunks, kit and grey fox, bobcat, collared peccary, and mule deer. Clemensen (1992) reports that fox, coyote, and bobcat have been seen at the monument.

Bats

We did not observe any bats during our inventory. Because of their high mobility, bats are much less dispersal-limited than most other mammals, and therefore could forage throughout the monument and

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[8] Based on a site visit (but no trapping), Yar Petryszyn (in Swann et al. 1994) believed that the cactus mouse would be the main native rodent that would forage in the Casa Grande structure.

the surrounding landscape. Therefore, we include a list of 18 species of bats that, based on range and habitat associations, could be present at Casa Grande Ruins NM (Appendix G). Of these, the Brazilian free-tailed bat is the only species that was once known to have bred at the monument (Clemensen 1992).

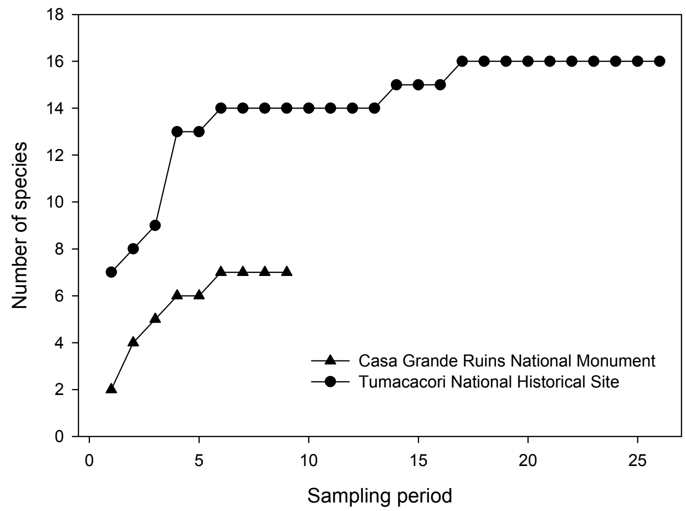

Figure 6.3. Species accumulation curve for small-mammal trapping at Casa Grande Ruins NM (2002) and Tumacácori National Historical Site (2001 and 2002; see Powell et al. 2004). Tumacácori data shown for comparison. One sampling period represents one trapping event (1–3 days) per plot.

DISCUSSION

Of all the groups that we studied, mammals are probably most affected by habitat fragmentation (Woodroffe and Ginsberg 1998) of the desert around the monument. In general, the home range of mammals is proportionate to body size; larger animals require more land for life-history functions (Jetz et al. 2004). We found no large mammals (e.g., mountain lion, deer, or bear) during our surveys and no large mammals have been reported for decades (Clemensen 1992, Carol West, *pers. com.* to Brian Powell). We observed or documented some medium-size mammals such as badger (skull), striped skunk (sighting), and feral cats and dogs (Table 6.2). Coyotes have been reported for the monument both historically (Clemensen 1992) and recently (Karen Monroe, *pers. com.*).

Although no baseline exists for quantitatively evaluating changes in the mammal community at the monument, it is logical to conclude that the surrounding land uses have negatively affected the native mammal community. The species richness and abundance of mammals have declined, and many of the permanent changes that we see today, such as no large mammals, may go back as early as the 1930s when the monument was surrounded by agricultural development (Clemensen 1992). One particularly striking change was the use of the Casa Grande by Brazilian ("Mexican") free-tailed bats. In 1944, monument personnel counted over 5,000 bats exiting the ruins, but by 1956 bats no longer lived on the monument (Clemensen 1992). This time period coincided with the increased use of insecticides, including DDT (see Chapter 2). More recently, Swann et al. (1994) did not find any bats or sign of bats on their inspection of the Casa Grande in the late summer and fall of 1993 nor did we find any bats during our surveys. Although free-tailed bats have a large foraging range (Best and Geluso 2003), the combination of pesticide use and subsequent lack of insects in areas adjacent to the monument may prevent the bats from returning. However, changes in the bat population on the regional scale may play a more important role in their return.

We were surprised to find a badger skull at the monument. Some features of the monument are probably ideal for badgers, such as alluvial soil for digging and an abundance of round-tailed ground squirrels, which are its main food source (Hoffmeister 1986). Badgers also provide nesting habitat for burrowing owls (Conway and Ellis 2004). With the increasing isolation of the monument from other undeveloped areas, it seems unlikely that badgers are now resident or will be in the future. It is unclear if the monument could sustain a badger population following a reintroduction effort.

CHAPTER 7: MANAGEMENT IMPLICATIONS

Based on the data from this study and our knowledge of the natural resource issues at the monument, we suggest issues that affect management of the monument's natural resources. Coordination with other agencies, non-governmental organizations, and/or adjacent landowners may prove the best route to resolving some of these issues.

Development Adjacent to the Monument
The most serious threat to the biological diversity of Casa Grande Ruins NM is continued commercial and residential development of adjacent and nearby lands. Potential impacts of residential development include: an increase in number and extent of non-native plants (see Chapter 3); increased runoff of toxins and sediment, disruption of animal movement patterns, and habitat loss and fragmentation (Mills et al. 1989, Theobald et al. 1997, Riley et al. 2003); and increased harassment and mortality of native animals by feral and free-roaming pets (Coleman and Temple 1993). The monument is considering the acquisition of agricultural land to the west of the monument; ecological restoration of degraded desert lands underway elsewhere may prove instructive if the National Park Service chooses to bring native vegetation back to the area. Martin Karpiscak (University of Arizona Office of Arid Lands Studies) has done restoration work around the Palo Verde nuclear power plant near Phoenix. Also, Ann Phillips at the Tucson Audubon Society is an expert on desert restoration and is working to rehabilitate a site along the lower Santa Cruz River (north of Tucson).

Managing Non-native and Pest Species
There are many non-native plants and animals that pose significant threats to the monument's resources, both cultural and biological. It is beyond the scope of this project to review specific control techniques for each species. Many National Park Service units have consulted experts and developed a non-native species management plan to guide future management decisions. The work by Halvorson and Guertin (2003) would provide an excellent foundation for this process.

As mentioned in Chapter 1, our study was not designed to assess habitat use by vertebrate species, therefore our results do not provide species-specific data to the ongoing pest management issue at the monument (NPS 1997). However, based on our data, a number of striking community-level patterns emerge. First, the bird community is dominated by generalist species, including rock pigeon, house finch, and house sparrow (which are considered pest species). Given the increasing urbanization of the area surrounding the monument, we expect an increasing prevalence of generalist species, and therefore concur with the assertion in the monument's integrated pest management plan (IPM; NPS 1997) that any management action for pest birds in the monument will have to be part of a larger, long-term regional effort. Yet given the limited financial resources of the monument, this seems unrealistic. The most feasible solution may be an exclosure devise or modification of the structure to eliminate habitat inside of the structure.

Round-tailed ground squirrel are considered the most important pest species at the monument because they are disturbing sensitive archaeological resources (Swann et al. 1994, NPS 1997). Unlike birds, it may be possible to significantly reduce the numbers of animals through trapping or poisoning. We agree with Swann et al. (1994) that modification of the existing habitat for round-tailed ground squirrels will likely have the most long lasting and desired effect.

Swann et al. (1994) and the monument's IPM plan (NPS 1997) both note the presence of burrows made by larger mammals, which were assumed to be made in pursuit of ground squirrels. Based on our data, and on observations by monument staff, it appears that native mammals such as coyote, kit and gray fox, and bobcat are very rare. Given the loss of habitat for these species in the surrounding landscape we suggest that these species should not be trapped or shot, as indicated in the pest management plan (NPS 1997).

CHAPTER 8: ADDITIONAL INVENTORIES AND RESEARCH

No inventory is ever truly complete; species distributions expand and contract across boundaries, particularly at small parks such as Casa Grande Ruins NM. In general, we feel that we have succeeded in balancing our efforts between qualitative surveys designed to detect the maximum number of species with quantitative, repeatable surveys designed to estimate relative abundance with an associated measure of precision. Additional inventories could reach the 90% completion mark for some taxonomic groups.

Monument managers are clearly interested in the effects that nearby land use and development have on the plants and vertebrates of the monument (NPS 2003a, 2003b). Given the small size of the monument, however, any study that investigates the monument's resources should be undertaken in the context of the larger landscape. For example, Conway and Ellis (2004) examined differences in reproductive success of burrowing owls between populations on the monument and those in nearby areas. This approach, which places the natural resources in the monument into a larger spatial and temporal context, puts NPS staff in a stronger position to maintain and enhance, or eliminate (e.g., non-native species) natural resources from the monument.

Plants

Additional general botanizing surveys, conducted during relatively wet years, should increase the species list for annual plants and possibly relocate species that were not recorded by our field crews but were found by others (Reichhardt 1992 and collections at the UA and WACC). We suggest that future surveys target sensitive areas such as along roadsides and on and around the mounds of sediment that are dredged from irrigation canals.

Specimens from the monument may be residing in the herbaria collections at Arizona State University and Northern Arizona University; there is currently a project underway to digitize those databases and the project should be completed in early 2005 (Phil Jenkins, *pers. com.*). Care should be taken, however, in accepting the list of species without confirming the proper identification of species or updating taxonomy (Halvorson 2003). Finally, use of modular plots throughout the monument would be an effective tool for monitoring long-term vegetation changes (see Powell et al. 2004).

Amphibians and Reptiles

An effective way to increase the species list for amphibians and reptiles is to take high-quality photographs of animals as they are seen. The collection of road-killed animals, particularly snakes, from along Highway 87 will likely add species to the inventory. Other inventory efforts in Sonoran Desert Network parks have benefited from collection of these indisputable forms of evidence by NPS staff (Don Swann, *pers. com.*). A more in-depth study of roadkill adjacent to the monument (and nearby areas as well) would help quantify the effects of roads on herpetofauna and mammal communities.

Birds

Additional surveys during the winter season and during the spring and fall migrations will pick up species missed by efforts at other times. It is important to note, however, that bird lists are difficult to complete because birds are highly mobile. Only sites that are visited regularly by avid bird watchers (e.g., Madera Canyon, Ramsey Canyon, and Sonoita Creek Preserve in southern Arizona) have bird lists that can be considered to be "complete."

Mammals

The use of ultrasonic detectors to identify bat species is increasing, and many researchers are refining the field techniques and improving the technology (e.g., Johnson et al. 2002, Gannon et al. 2003). These technologies may become more useful in the coming years with these refinements.

Our Trailmaster camera effort was inadequate for documenting medium and large mammals, despite having the cameras operating for over three months. Because infrared-triggered cameras are the best method for documenting medium and large mammals, we recommend establishing the camera in a number of locations and having monument staff check the cameras on a regular basis; camera operation and maintenance is a fairly simple and rewarding task for technically proficient staff members. Care must be taken in determining where to place camera units because of the potential for cameras to be damaged or stolen.

Round-tailed ground squirrels are considered a pest species by the monument (NPS 1997) because they are causing damage to the numerous structures at the monument. We did not attempt to quantify the population size or distribution of the species in the monument. If an attempt is made at reducing or eliminating round-tailed ground squirrels from the monument, we suggest a capture-recapture study (Nichols and Dickman 1996) to determine the population size before and after any action. This will help to determine if the action was successful at reaching target population levels.

CHAPTER 9: LITERATURE CITED

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CHAPTER 10: GLOSSARY

Abundance: Number of individuals (or groups, clusters), expressed in relative or absolute terms.

Accuracy: Closeness of a measured value to the true value (see precision).

Community species richness: Number of species in a grouping, which may be delineated at various scales and perspectives (e.g., functional, geographic, taxonomic). True richness is seldom known and in this report we present recorded richness.

Density: Number of individuals scaled by unit of area or volume (e.g., four chipping sparrows/hectare).

Documented: Species was verified by evidence: voucher specimen (or parts of a specimen) or photograph (see observed and recorded).

Ecological community: A collection of populations in a defined (spatial and temporal) location (e.g., breeding birds at Casa Grande Ruins NM).

Ecological population: A group of individuals of the same species in a defined location (e.g., mourning doves at Casa Grande Ruins NM).

Habitat: A species-specific term that generally refers to an area with resources and environmental conditions to promote occupancy, survival, and reproduction of that species (Morrison et al. 1998: p. 10).

n: Sample size; number of sample units.

N: Total number of samples taken or number of samples from which to choose.

Neotropical migrants: bird species that include populations breeding north and wintering south of the Tropic of Cancer (Rappole 1995: 173–182).

Observed: Species or individual seen and/or heard by a reliable observer (see documented and recorded).

Pishing: A common method to attract birds using a high-pitched and varied call. Often bring birds closer to the observer.

Precision: Closeness of repeated measurement to each other (see accuracy).

Recorded: Species or individual observed and/or documented (see observed and documented).

Relative abundance: An index to abundance, usually the number of individuals (groups, clusters) recorded in a survey, scaled by survey effort (e.g., five gopher snakes per person-hour) and presented as a mean of all surveys, with an estimate of precision (e.g., standard error).

Standard error (SE): The standard deviation of a mean divided by the square of *n*; a measure of the precision of an estimate (e.g., sample mean).

Standard deviation: The square root of variance, which is the average of squared deviations from the mean. Deviation from mean is the difference between individual samples and the mean of all samples.

Appendix A. List of plant species observed or documented at Casa Grande Ruins NM by University of Arizona Inventory personnel ("I&M"), 2001 and 2002 or other studies or collections: Halvorson and Guertin (2003) ("Halvor"), Reichhardt (1992) ("Reichht"), specimens at the University of Arizona ("UA") or the Western Archeological Conservation Center ("WACC"). Species in bold-faced type are non-native.

Family	Scientific name	Common name	I&M	Halvor	Reichht[a]	UA[b]	WACC
Apiaceae	*Bowlesia incana* Ruiz & Pavón	hoary bowlesia	X		X		
Apocynaceae	***Nerium oleander* L.**	**oleander**			**X**		
Asclepiadaceae	*Funastrum cynanchoides* (Dcne.) Schlechter ssp. heterophyllum (Vail) Kartesz, comb. nov. ined.	Hartweg's twinevine	X				
Asteraceae	*Acourtia nana* (Gray) Reveal & King	dwarf desertpeony	X				
	Ambrosia psilostachya DC.	Cuman ragweed			X		
	Antheropeas lanosum (Gray) Rydb.	white easterbonnets	X		X	X	
	Aphanostephus ramosissimus DC. var. humilis (Benth.) B.L. Turner & Birdsong	plains dozedaisy				X	
	Baccharis sarothroides Gray	desertbroom	X				
	Baileya multiradiata Harvey & Gray ex Gray	desert marigold			X		X
	***Centaurea melitensis* L.**	**Maltese star-thistle**		**X**	**X**		
	Conyza canadensis (L.) Cronq.	Canadian horseweed		X			
	***Dimorphotheca sinuata* DC.**	**glandular cape marigold**		**X**			
	Erigeron divergens Torr. & Gray	spreading fleabane			X		X
	Evax verna Raf. var. verna Raf.	spring pygmycudweed	X				
	Filago arizonica Gray	Arizona cottonrose	X				
	Helianthus annuus L.	common sunflower			X	X	X
	Heterotheca subaxillaris (Lam.) Britt. & Rusby	camphorweed				X	X
	Isocoma acradenia (Greene) Greene	alkali goldenbush				X	
	Isocoma pluriflora (Torr. & Gray) Greene	southern goldenbush			X		X
	***Lactuca serriola* L.**	**prickly lettuce**		**X**			
	Laennecia coulteri (Gray) Nesom	conyza			X	X	
	Laennecia schiedeana (Less.) Nesom	pineland marshtail					X
	Lasthenia californica DC. ex Lindl.	California goldfields	X		X		X
	Machaeranthera arida B.L. Turner & Horne	arid tansyaster	X			X	X
	***Matricaria discoidea* DC.**	**disc mayweed**				**X**	**X**
	Pectis papposa Harvey & Gray	manybristle cinchweed	X		X	X	X
	***Sonchus asper* (L.) Hill**	**spiny sowthistle**	**X**			**X**	
	***Sonchus oleraceus* L.**	**common sowthistle**			**X**	**X**	**X**
	Stephanomeria pauciflora (Torr.) A. Nels.	brownplume wirelettuce			X		X
	Verbesina encelioides (Cav.) Benth. & Hook. f. ex Gray	golden crownbeard	X			X	X
	Verbesina encelioides (Cav.) Benth. & Hook. f. ex Gray ssp. exauriculata (Robins. & Greenm.) J.R. Coleman	golden crownbeard			X		
Boraginaceae	*Amsinckia menziesii* (Lehm.) A. Nels. & J.F. Macbr. var. intermedia (Fisch & C.A. Mey.) Ganders	common fiddleneck	X		X	X	
	Amsinckia tessellata Gray	bristly fiddleneck			X	X	X
	Cryptantha angustifolia (Torr.) Greene	Panamint cryptantha	X		X		X
	Lappula occidentalis (S. Wats.) Greene var. occidentalis (S. Wats.) Greene	flatspine stickseed	X			X	
	Pectocarya heterocarpa (I.M. Johnston) I.M. Johnston	chuckwalla combseed	X		X	X	
	Pectocarya penicillata (Hook. & Arn.) A. DC.	sleeping combseed			X		
	Pectocarya platycarpa (Munz & Johnston) Munz & Johnston	broadfruit combseed			X		
	Plagiobothrys arizonicus (Gray) Greene ex Gray	Arizona popcornflower	X		X	X	
Brassicaceae	***Brassica tournefortii* Gouan**	**Asian mustard**	**X**	**X**	**X**		**X**
	Descurainia pinnata (Walt.) Britt.	western tansymustard	X			X	X
Brassicaceae	*Descurainia pinnata* (Walt.) Britt. ssp. pinnata	western tansymustard			X		

Family	Scientific name	Common name	I&M	Halvor	Reichht [a]	UA [b]	WACC
	(Walt.) Britt.						
	***Descurainia sophia* (L.) Webb ex Prantl**	**herb sophia**		**X**			
	Lepidium lasiocarpum Nutt.	shaggyfruit pepperweed	X		X	X	X
	Lesquerella tenella A. Nels.	Moapa bladderpod				X	
	***Sisymbrium irio* L.**	**London rocket**	**X**	**X**	**X**	**X**	**X**
Cactaceae	*Carnegia gigantea* (Engelm.) Britt. & Rose	saguaro	X		X		
	Ferocactus wislizeni (Engelm.) Britt. & Rose	candy barrelcactus	X				
Chenopodiaceae	*Atriplex canescens* (Pursh) Nutt.	fourwing saltbush			X		X
	Atriplex elegans (Moq.) D. Dietr.	wheelscale saltbush			X		X
	Atriplex polycarpa (Torr.) S. Wats.	cattle saltbush			X		
	***Chenopodium murale* L.**	**nettleleaf goosefoot**	**X**	**X**	**X**		**X**
	Monolepis nuttalliana (J.A. Schultes) Greene	Nuttall's povertyweed			X		X
	***Salsola tragus* L.**	**prickly Russian thistle**			**X**		**X**
	Suaeda moquinii (Torr.) Greene	Mohave seablite			X		
Cucurbitaceae	*Cucurbita digitata* Gray	fingerleaf gourd					X
Euphorbiaceae	*Chamaesyce albomarginata* (Torr. & Gray) Small	whitemargin sandmat			X		X
	Chamaesyce micromera (Boiss. ex Engelm.) Woot. & Standl.	Sonoran sandmat	X				
	Chamaesyce polycarpa (Benth.) Millsp. ex Parish	smallseed sandmat	X				
Fabaceae	*Acacia greggii* Gray	catclaw acacia			X		
	Astragalus didymocarpus Hook. & Arn.	dwarf white milkvetch	X				
	Calliandra eriophylla Benth.	fairyduster				X	
	Lotus strigosus (Nutt.) Greene var. tomentellus (Greene) Isely	strigose bird's-foot trefoil	X				
	Lupinus sparsiflorus Benth.	Mohave lupine	X			X	
	***Melilotus indicus* (L.) All.**	**annual yellow sweetclover**	**X**	**X**			
	Parkinsonia florida (Benth. ex Gray) S. Wats.	blue paloverde			X		
	Prosopis glandulosa Torr.	honey mesquite			X		
	Prosopis velutina Woot.	velvet mesquite	X		X		
Fumariaceae	*Corydalis curvisiliqua* Engelm. ssp. occidentalis (Engelm. ex Gray) W.A. Weber	curvepod fumewort				X	
Geraniaceae	***Erodium cicutarium* (L.) L'Hér. ex Ait.**	**redstem stork's bill**	**X**	**X**	**X**		**X**
	Erodium texanum Gray	Texas stork's bill	X		X	X	
Hydrophyllaceae	*Emmenanthe penduliflora* Benth.	whisperingbells				X	
	Eucrypta micrantha (Torr.) Heller	dainty desert hideseed			X		
	Nama demissum Gray	purplemat				X	
	Nama hispidum Gray	bristly nama	X		X	X	X
	Phacelia crenulata Torr. ex S. Wats.	cleftleaf wild heliotrope					X
	Phacelia crenulata Torr. ex S. Wats. var. ambigua (M.E. Jones) J.F. Macbr.	purplestem phacelia				X	
	Phacelia distans Benth.	distant phacelia	X		X	X	X
Lamiaceae	*Salvia columbariae* Benth.	chia				X	
	Teucrium cubense Jacq. var. densum Jepson	small coastal germander	X				
Loasaceae	*Mentzelia pumila* Nutt. ex Torr. & Gray var. pumila Nutt. ex Torr. & Gray	dwarf mentzelia	X				
Malvaceae	***Malva parviflora* L.**	**cheeseweed mallow**	**X**	**X**			
	Sphaeralcea ambigua Gray	desert globemallow	X				
	Sphaeralcea coulteri (S. Wats.) Gray	Coulter's globemallow	X				
	Sphaeralcea emoryi Torr. ex Gray	Emory's globemallow				X	
	Sphaeralcea laxa Woot. & Standl.	caliche globemallow			X		
	Sphaeralcea orcuttii Rose	Carrizo Creek globemallow	X				
Nyctaginaceae	*Boerhavia coccinea* P. Mill.	scarlet spiderling		X			
Onagraceae	*Camissonia claviformis* (Torr. & Frém.) Raven ssp. peeblesii (Munz) Raven	Peebles' browneyes	X			X	
Onagraceae	*Oenothera caespitosa* Nutt.	tufted evening-primrose			X		X

Family	Scientific name	Common name	I&M	Halvor	Reichht [a]	UA [b]	WACC
	Oenothera primiveris Gray	desert evening-primrose	X		X		X
	Oenothera primiveris Gray ssp. primiveris	desert evening-primrose				X	
Papaveraceae	*Argemone pleiacantha* Greene ssp. pinnatisecta G.B. Ownbey	southwestern pricklypoppy					X
	Eschscholzia californica Cham. ssp. mexicana (Greene) C. Clark	California poppy	X		X	X	
Plantaginaceae	*Plantago ovata* Forsk.	desert Indianwheat	X		X	X	X
Poaceae	*Aristida purpurea* Nutt.	purple threeawn			X		
	***Avena fatua* L.**	**wild oat**		**X**			
	Bromus carinatus Hook. & Arn.	California brome	X	X			
	***Bromus rubens* L.**	**red brome**	**X**	**X**	**X**		**X**
	***Cynodon dactylon* (L.) Pers.**	**Bermudagrass**		**X**	**X**	**X**	
	***Eragrostis lehmanniana* Nees**	**Lehmann lovegrass**		**X**	**X**		
	***Hordeum murinum* L. ssp. glaucum (Steud.) Tzvelev**	**smooth barley**	**X**	**X**			
	***Hordeum murinum* L. ssp. leporinum (Link) Arcang.**	**leporinum barley**			**X**		**X**
	***Hordeum vulgare* L.**	**common barley**		**X**			
	***Pennisetum ciliare* (L.) Link**	**buffelgrass**		**X**			
	***Phalaris minor* Retz.**	**littleseed canarygrass**	**X**	**X**			
	Poa bigelovii Vasey & Scribn.	Bigelow's bluegrass	X		X	X	
	***Schismus arabicus* Nees**	**Arabian schismus**	**X**	**X**	**X**		
	***Schismus barbatus* (Loefl. ex L.) Thellung**	**common Mediterranean grass**		**X**	**X**		**X**
	***Sorghum halepense* (L.) Pers.**	**Johnsongrass**		**X**			
	Vulpia octoflora (Walt.) Rydb.	sixweeks fescue	X				
Polemoniaceae	*Eriastrum diffusum* (Gray) Mason	miniature woollystar	X				
Polygonaceae	*Eriogonum fasciculatum* Benth. var. polifolium (Benth.) Torr. & Gray	Eastern Mohave buckwheat				X	
	***Polygonum argyrocoleon* Steud. ex Kunze**	**silversheath knotweed**			**X**	**X**	
	Polygonum aviculare L.	prostrate knotweed		X			
Resedaceae	*Oligomeris linifolia* (Vahl) J.F. Macbr.	lineleaf whitepuff	X				
Scrophulariaceae	*Castilleja exserta* (Heller) Chuang & Heckard ssp. exserta (Heller) Chuang & Heckard	exserted Indian paintbrush	X				
Solanaceae	*Lycium exsertum* Gray	Arizona desert-thorn			X		
	Lycium fremontii Gray	Fremont's desert-thorn	X				
	***Nicotiana glauca* Graham**	**tree tobacco**	**X**	**X**	**X**		**X**
	Nicotiana obtusifolia Mertens & Galeotti var. obtusifolia Mertens & Galeotti	desert tobacco	X		X	X	X
	Physalis acutifolia (Miers) Sandw.	sharpleaf groundcherry				X	X
Tamaricaceae	***Tamarix chinensis* Lour.**	**fivestamen tamarisk**			**X**		**X**
Viscaceae	*Phoradendron californicum* Nutt.	mesquite mistletoe			X	X	X
Zygophyllaceae	*Larrea tridentata* (Sessé & Moc. ex DC.) Coville	creosote bush	X		X		X
	Tribulus terrestris L.	**puncturevine**		**X**			
Number of species			**60**	**27**	**64**	**43**	**43**
Number of non-native species			**12**	**23**	**17**	**6**	**12**
Percent non-native species			**20**	**85**	**26**	**14**	**28**
Number of species unique to study or collection			**21**	**11**	**16**	**15**	**3**

[a] Underlined species were reported in Reichhardt (1992) but collected by another individual. Some of these specimens are in the herbarium at the Arizona State University or at WACC.

[b] All specimens were collected from 1939-1942 except *Phacelia distans*, which was collected in 1916.

Appendix B. Amphibian and reptile species documented with photo voucher (P) or specimen voucher (S) by University of Arizona Inventory personnel, Casa Grande Ruins NM, 2001 and 2002. See Appendix M for additional information on voucher specimens and photographs.

Order	Family	Scientific name	Common name	Type of documentation
Anura	Pelobatidae	*Scaphiopus couchii*	Couch's spadefoot	S
	Bufonidae	*Bufo alvarius*	Sonoran desert toad	P
		Bufo cognatus	Great Plains toad	P
Squamata	Gekkonidae	*Coleonyx variegatus*	western banded gecko	P
	Phrynosomatidae	*Sceloporus magister* [a]	desert spiny lizard	P
		Uta stansburiana [a]	common side-blotched lizard	P
		Urosaurus graciosus [a]	long-tailed brush lizard	P
	Teiidae	*Cnemidophorus tigris* [a]	western (tiger) whiptail	P
	Colubridae	*Masticophis flagellum* [a]	coachwhip	P
		Pituophis catenifer	gopher snake	P
		Lampropeltis getula	common kingsnake	P
		Rhinocheilus lecontei [a]	long-nosed snake	P
	Viperidae	*Crotalus atrox*	western diamond-backed rattlesnake	P
		Crotalus scutulatus [a]	Mohave rattlesnake	P

[a] Also found by Charles Conner (*pers. com.*).

Appendix C. Number of observations of bird species, by survey type, at Casa Grande Ruins NM by University of Arizona Inventory personnel, 2001 and 2002. Numbers of individuals recorded are not scaled by search effort and should not to be used for comparison among species. Underlined species are neotropical migrants (Rappole 1995). Species in bold-faced type are non-native.

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				Number of individuals by survey type			
Order	Family	Scientific name	Common name	VCP	Line transect	Nocturnal	Incidental
Anseriformes	Anatidae	*Anas platyrhynchos*	mallard	4			
Galliformes	Odontophoridae	*Callipepla gambelii*	Gambel's quail	140	1		1
	Ardeidae	*Ardea herodias*	great blue heron		1		
		Ardea alba	great egret [a]		1		1
	Cathartidae	*Cathartes aura*	turkey vulture				1
Falconiformes	Accipitridae	*Circus cyaneus*	northern harrier	1	2		1
		Accipiter cooperii	Cooper's hawk		2		1
		Parabuteo unicinctus	Harris's hawk				1
		Buteo swainsoni	Swainson's hawk	1			
		Buteo jamaicensis	red-tailed hawk	1	2		2
		Buteo regalis	ferruginous hawk [a, b]				1
	Falconidae	*Falco sparverius*	American kestrel	15	1		1
		Falco columbarius	merlin		1		
		Falco peregrinus	peregrine falcon [a, b, c]		1		
		Falco mexicanus	prairie falcon	2			
Gruiformes	Gruidae	*Grus canadensis*	sandhill crane	12			
Charadriiformes	Charadriidae	*Charadrius vociferus*	killdeer	1	1		
	Recurvirostridae	*Himantopus mexicanus*	black-necked stilt	2			
Columbiformes	Columbidae	***Columba livia***	**rock pigeon**	113	28		
		Zenaida asiatica	white-winged dove	33			
		Zenaida macroura	mourning dove	507	89		6
		Columbina inca	Inca dove	2			3
Cuculiformes	Cuculidae	*Geococcyx californianus*	greater roadrunner	1			
Strigiformes	Tytonidae	*Tyto alba*	barn owl			2	1
	Strigidae	*Bubo virginianus*	great horned owl			5	
		Athene cunicularia hypugaea	burrowing owl [b, d]	17	2	4	6

				Number of individuals by survey type			
Order	Family	Scientific name	Common name	VCP	Line transect	Nocturnal	Incidental
Caprimulgiformes	Caprimulgidae	*Chordeiles acutipennis*	lesser nighthawk	13		16	8
		Phalaenoptilus nuttallii	common poorwill				3
Apodiformes	Trochilidae	*Archilochus alexandri*	black-chinned hummingbird	14	1		2
		Calypte anna	Anna's hummingbird	20	19		
		Calypte costae	Costa's hummingbird	2	2		
Piciformes	Picidae	*Melanerpes uropygialis*	Gila woodpecker [c]	23			
		Picoides scalaris	ladder-backed woodpecker	1			
		Colaptes auratus	northern flicker		1		
		Colaptes chrysoides	gilded flicker [c]	29	10		3
Passeriformes	Tyrannidae	*Contopus sordidulus*	western wood-pewee	3			1
		Empidonax wrightii	gray flycatcher	1			
		Sayornis saya	Say's phoebe	1	6		
		Myiarchus cinerascens	ash-throated flycatcher	19			2
		Tyrannus verticalis	western kingbird	11			
	Laniidae	*Lanius ludovicianus*	loggerhead shrike [b]	4	7		1
	Corvidae	*Corvus corax*	common raven	6	2		
	Alaudidae	*Eremophila alpestris*	horned lark	24			
	Hirundinidae	*Petrochelidon pyrrhonota*	cliff swallow	335			
	Remizidae	*Auriparus flaviceps*	verdin	15	2		2
Passeriformes	Troglodytidae	*Salpinctes obsoletus*	rock wren		4		
Passeriformes	Troglodytidae	*Campylorhynchus brunneicapillus*	cactus wren	19			3
	Sylviidae	*Polioptila caerulea*	blue-gray gnatcatcher		7		1
		Polioptila melanura	black-tailed gnatcatcher	1			1
	Mimidae	*Mimus polyglottos*	northern mockingbird	25	1		
		Toxostoma curvirostre	curve-billed thrasher	1			
	Sturnidae	***Sturnus vulgaris***	**European starling**	59	1		1
	Motacillidae	*Anthus rubescens*	American pipit	1	2		
	Ptilogonatidae	*Phainopepla nitens*	phainopepla	1			
	Parulidae	*Vermivora celata*	orange-crowned warbler	1			
		Vermivora ruficapilla	Nashville warbler	1			1
		Vermivora virginiae	Virginia's warbler	1			
		Vermivora luciae	Lucy's warbler	1			
		Dendroica petechia	yellow warbler	1			
		Dendroica coronata	yellow-rumped warbler	3	26		1
		Dendroica nigrescens	black-throated gray warbler				1
		Oporornis tolmiei	MacGillivray's warbler	1			
		Wilsonia pusilla	Wilson's warbler	3			2
	Thraupidae	*Piranga ludoviciana*	western tanager	1			
	Emberizidae	*Pipilo chlorurus*	green-tailed towhee	1			1
		Spizella passerina	chipping sparrow	4			
		Spizella breweri	Brewer's sparrow	130			
		Spizella atrogularis	black-chinned sparrow				1
		Pooecetes gramineus	vesper sparrow	1			
		Chondestes grammacus	lark sparrow	2			
		Calamospiza melanocorys	lark bunting	77			
		Zonotrichia leucophrys	white-crowned sparrow	3	46		
	Icteridae	*Agelaius phoeniceus*	red-winged blackbird	106			
		Sturnella neglecta	western meadowlark				1
		Quiscalus mexicanus	great-tailed grackle	111	75		
		Molothrus aeneus	bronzed cowbird				1

				Number of individuals by survey type			
Order	Family	Scientific name	Common name	VCP	Line transect	Nocturnal	Incidental
		Molothrus ater	brown-headed cowbird	4			
		Icterus bullockii	Bullock's oriole	5			1
	Fringillidae	*Carpodacus mexicanus*	house finch	131	19		2
	Fringillidae	*Carduelis psaltria*	lesser goldfinch	3			
	Passeridae	***Passer domesticus***	**house sparrow**	95	4		6
Number of species				**63**	**32**	**4**	**36**

[a] "Wildlife of Special Concern"; Arizona Game and Fish Department (HDMS 2004).
[b] "Species of Concern"; U.S. Fish and Wildlife Service (HDMS 2004).
[c] "Priority species"; Arizona Partners in Flight (Latta et al. 1999).
[d] "Sensitive species"; Bureau of Land Management (HDMS 2004).

Appendix D. Mammal species observed or documented by University of Arizona Inventory personnel, Casa Grande Ruins NM, 2001 and 2002. Species in bold-faced type are non-native.

Order	Family	Scientific name	Common name
Carnivora	Mustelidae	*Taxidea taxus*	American badger
	Mephitidae	*Mephitis mephitis*	striped skunk
	Canidae	***Canis familiaris***	**domestic dog**
	Felidae	***Felis catus***	**domestic cat**
Rodentia	Sciuridae	*Spermophilus tereticaudus*	round-tailed ground squirrel
	Heteromyidae	*Perognathus amplus taylori*	Arizona pocket mouse
		Chaetodipus penicillatus	Sonoran Desert pocket mouse
		Dipodomys merriami	Merriam's kangaroo rat
	Muridae	*Peromyscus maniculatus*	deer mouse
		Onychomys torridus	southern grasshopper mouse
		Neotoma albigula	western white-throated woodrat
Lagomorpha	Leporidae	*Lepus californicus*	black-tailed jackrabbit
		Sylvilagus audubonii	desert cottontail

Appendix E. Amphibian and reptile species not recorded by University of Arizona Inventory personnel but that are likely to occur or may have occurred historically at Casa Grande Ruins NM based on collections in the area and expert opinion (Rosen in Appendix N). Species in bold-faced type are non-native.

			Presence		Voucher Specimens[a]	
Order / Family	Scientific name	Common name	Expected	Not expected[b]	Monument[c]	Surrounding lands[d]
Caudata						
Ambystomatidae	***Ambystoma tigrinum***	**tiger salamander**		X		1
Anura						
Pelobatidae	*Spea multiplicata*	Mexican spadefoot	X			
Bufonidae	*Bufo woodhousii*	Woodhouse's toad		X		10
Ranidae	*Rana yavapaiensis*	lowland leopard frog		X		
	Rana catesbeiana	**American bullfrog**		X		3
Testudines						
Kinosternidae	*Kinosternon sonoriense*	Sonoran mud turtle		X		
Emydidae	*Terrapene ornata*	western box turtle		X		
Testudinidae	*Gopherus agassizii sonoran*	desert tortoise				
Trionychidae	***Trionyx spiniferus***	**spiny softshell**		X		1
Squamata						
Iguanidae	*Dipsosaurus dorsalis*	desert iguana				40
	Sauromalus obesus	common chuckwalla				2
Crotaphytidae	*Crotaphytus nebrius*	Sonoran collared lizard				1
	Gambelia wislizenii	long-nosed leopard lizard				9
Phrynosomatidae	*Callisaurus draconoides*	zebra-tailed lizard				91
	Sceloporus clarkii	Clark's spiny lizard				
	Urosaurus ornatus	ornate tree lizard				
	Phrynosoma platyrhinos	desert horned lizard				35
	Phrynosoma solare	regal horned lizard				5
Helodermatidae	*Heloderma suspectum*	Gila monster				23
Leptotyphlopidae	*Leptotyphlops humilis*	western blind snake			1	3
Colubridae	*Phyllorhynchus decurtatus*	spotted leaf-nosed snake	X		1	3
	Phyllorhynchus browni	saddled leaf-nosed snake	X			2
	Chilomeniscus cinctus	variable sand snake			1	3
	Salvadora hexalepis	western patch-nosed snake				1
	Arizona elegans	glossy snake				17
	Thamnophis eques	Mexican garter snake		X		
	Thamnophis marcianus	checkered garter snake		X		5
	Sonora semiannulata	western ground snake	X			3
	Chionactis occipitalis	western shovel-nosed snake	X		2	6
	Tantilla hobartsmithi	southwestern black-headed snake				1
	Hypsiglena torquata	night snake	X			4
Viperidae	*Crotalus cerastes*	sidewinder				23
	Crotalus molossus	black-tailed rattlesnake				1

[a] Data from Rosen. Due to proprietary information, we cannot report collection information associated with these specimens except those specimens referenced in Appendix L.

[b] Riparian-associated species. May have been present historically but not likely present in the monument now (see Appendix N).

[c] Specimen collected at Casa Grande Ruins NM. Data from Rosen (Appendix N) or Appendix L.

[d] Museum locality records for the area of Casa Grande National Monument and surrounding Pinal County, taken from an area of largely homogeneous, lowland desert flats, bounded roughly by the communities of Maricopa, Queen Creek, Florence Junction, Florence, and Casa Grande.

Appendix F. Bird species that were not recorded by University of Arizona Inventory personnel but that may occur at Casa Grande Ruins NM. List based on range maps (Sibley 2000), nearby Breeding Bird Survey routes (Sauer et al. 2004) and knowledge of physical conditions at the monument. Species on this list are those most likely to occur and not those considered "accidental" (<5 observations in many areas of southern Arizona).

Order	Family	Scientific name	Common name
Ciconiiformes	Cathartidae	*Coragyps atratus*[a]	black vulture
Falconiformes	Accipitridae	*Buteo albonotatus*	zone-tailed hawk
		Aquila chrysaetos	golden eagle
Columbiformes	Columbidae	*Columbina passerina*[b]	common ground-dove
Strigiformes	Strigidae	*Megascops kennicottii*	western screech-owl
		Micrathene whitneyi	elf owl
		Asio otus	long-eared owl
Apodiformes	Apodidae	*Aeronautes saxatalis*	white-throated swift
	Trochilidae	*Selasphorus rufus*	rufous hummingbird
Piciformes	Picidae	*Melanerpes lewis*	Lewis's woodpecker
		Sphyrapicus nuchalis	red-naped sapsucker
Passeriformes	Tyrannidae	*Contopus cooperi*[a]	olive-sided flycatcher
		Empidonax hammondii	Hammond's flycatcher
		Empidonax oberholseri	dusky flycatcher
		Empidonax difficilis	pacific-slope flycatcher
		Empidonax occidentalis	cordilleran flycatcher
		Sayornis nigricans	black phoebe
		Pyrocephalus rubinus	vermilion flycatcher
		Myiarchus tuberculifer	dusky-capped flycatcher
		Myiarchus tyrannulus[a]	brown-crested flycatcher
		Tyrannus vociferans	Cassin's kingbird
	Vireonidae	*Vireo bellii*	Bell's vireo
		Vireo vicinior	gray vireo
		Vireo plumbeus	plumbeous vireo
		Vireo cassinii	Cassin's vireo
		Vireo huttoni	Hutton's vireo
		Vireo gilvus	warbling vireo
	Corvidae	*Aphelocoma californica*	western scrub-jay
	Hirundinidae	*Progne subis*	purple martin
		Tachycineta bicolor	tree swallow
		Hirundo rustica	barn swallow
	Aegithalidae	*Psaltriparus minimus*	bushtit
	Troglodytidae	*Catherpes mexicanus*	canyon wren
		Thryomanes bewickii	Bewick's wren
		Troglodytes aedon	house wren
	Regulidae	*Regulus calendula*	ruby-crowned kinglet
	Turdidae	*Sialia mexicana*	western bluebird
		Sialia currucoides	mountain bluebird
		Myadestes townsendi	Townsend's solitaire
		Catharus ustulatus	Swainson's thrush
		Catharus guttatus	hermit thrush
	Mimidae	*Toxostoma bendirei*[a]	Bendire's thrasher
		Toxostoma lecontei[b]	LeConte's thrasher
		Toxostoma crissale	crissal thrasher
	Bombycillidae	*Bombycilla cedrorum*	cedar waxwing
	Parulidae	*Dendroica townsendi*	Townsend's warbler
	Emberizidae	*Pipilo fuscus*	canyon towhee
		Aimophila cassinii	Cassin's sparrow

Order	Family	Scientific name	Common name
Passeriformes	Emberizidae	*Aimophila ruficeps*	rufous-crowned sparrow
		Spizella atrogularis	black-chinned sparrow
		Junco hyemalis	dark-eyed junco
	Cardinalidae	*Cardinalis cardinalis*	northern cardinal
		Cardinalis sinuatus	pyrrhuloxia
		Pheucticus melanocephalus	black-headed grosbeak
		Guiraca caerulea	blue grosbeak
		Passerina amoena	lazuli bunting
		Passerina cyanea	indigo bunting
	Icteridae	*Xanthocephalus xanthocephalus*	yellow-headed blackbird
		Euphagus cyanocephalus	Brewer's blackbird
		Icterus cucullatus	hooded oriole
		Icterus parisorum	Scott's oriole
	Fringillidae	*Coccothraustes vespertinus*	evening grosbeak

[a] Observed on “Cactus Forest” Breeding Bird Survey route (Sauer et al. 2004).
[b] Observed on “Coolidge” Breeding Bird Survey route (Sauer et al. 2004).

Appendix G. Mammal species not recorded by University of Arizona Inventory personnel but that may be found at Casa Grande Ruins NM based on known habitat associations and geographic range. Burt and Grossenheider (1976) was used only for range maps of bats.

Order	Family	Scientific name	Common name	Burt and Grossenheider (1976)	Hoffmeister (1986)
Insectivora	Soricidae	*Notiosorex crawfordi*	Crawford's desert shrew[a]		X
		Notiosorex cockrumi	Cockrum's desert shrew		
Chiroptera	Phyllostomidae	*Macrotus californicus*	California leaf-nosed bat	X	X
		Leptonycteris curasoae	southern long-nosed bat	X	X
	Vespertilionidae	*Myotis lucifugus*	little brown myotis	X	
		Myotis occultus	Arizona myotis	X	
		Myotis yumanensis	Yuma myotis	X	
		Myotis velifer	cave myotis	X	X
		Myotis thysanodes	fringed myotis	X	X
		Myotis volans	long-legged myotis	X	
		Myotis californicus	California myotis	X	
		Pipistrellus hesperus	western pipistrelle	X	
		Lasiurus xanthinus	western yellow bat	X	X
		Euderma maculatum	spotted bat	X	
		Corynorhinus townsendii	Townsend's big-eared bat	X	
		Antrozous pallidus	pallid bat	X	
	Molossidae	*Tadarida brasiliensis*	Brazilian free-tailed bat	X	
		Nyctinomops femorosaccus	pocketed free-tailed bat	X	X
		Nyctinomops macrotis	big free-tailed bat	X	
		Eumops perotis californicus	western bonneted bat	X	X
Carnivora	Procyonidae	*Procyon lotor*	northern raccoon		X
	Mephitidae	*Spilogale gracilis*	spotted skunk		X
		Mephitis macroura	hooded skunk		X
		Conepatus mesoleucus	white-backed hog-nosed skunk		X
	Canidae	*Canis latrans*	coyote		X
		Vulpes macrotis	kit fox		X
		Urocyon cinereoargenetus	gray fox		X
	Felidae	*Lynx rufus*	bobcat		X
Rodentia	Sciuridae	*Neotamias dorsalis*	cliff chipmunk		X
		Ammospermophilus harrisii	Harris' antelope squirrel		X
	Geomyidae	*Thomomys bottae*	Botta's pocket gopher		X
	Heteromyidae	*Perognathus longimembris*	Little pocket mouse		X
		Perognathus flavus	Silky pocket mouse		X
		Chaetodipus intermedius	rock pocket mouse		X
		Chaetodipus baileyi	Bailey's pocket mouse		X
		Dipodomys ordii	Ord's kangaroo rat		X
		Dipodomys spectabilis	Banner-tailed kangaroo rat		X
	Muridae	*Reithrodontomys megalotis*	western harvest mouse		X
		Reithrodontomys montanus	plains harvest mouse		X
		Peromyscus eremicus	cactus mouse		X
		Peromyscus merriami	Merriam's mouse		X
		Sigmodon arizonae	Arizona cotton rat		X
		Mus musculus	house mouse		X
Lagomorpha	Leporidae	*Lepus alleni*	antelope jackrabbit		X
Artiodactyla	Tayassuidae	*Pecari tajacu*	collared peccary		X
	Cervidae	*Odocoileus hemionus*	mule deer		X

[a] Baker et al. (2003)

Appendix H. UTM coordinates (NAD 83) for intensive plots for amphibian and reptile surveys, Casa Grande Ruins NM, 2001 and 2002. Accuracy is ± 15 m.

Plot name	Corner	Easting	Northing	Plot name	Corner	Easting	Northing
01	NE	449638	3651693	26	NE	449838	3651093
	NW	449438	3651693		NW	449638	3651093
	SE	449638	3651493		SE	449838	3650893
	SW	449438	3651493		SW	449638	3650893
03	NE	450038	3651693	27	NE	450038	3651093
	NW	449838	3651693		NW	449838	3651093
	SE	450038	3651493		SE	450038	3650893
	SW	449838	3651493		SW	449838	3650893
04	NE	450238	3651693	28	NE	450238	3651093
	NW	450038	3651693		NW	450038	3651093
	SE	450238	3651493		SE	450238	3650893
	SW	450038	3651493		SW	450038	3650893
10	NE	449838	3651493	30	NE	450638	3651093
	NW	449638	3651493		NW	450438	3651093
	SE	449838	3651293		SE	450638	3650893
	SW	449638	3651293		SW	450438	3650893
11	NE	450038	3651493	33	NE	449638	3650893
	NW	449838	3651493		NW	449438	3650893
	SE	450038	3651293		SE	449638	3650693
	SW	449838	3651293		SW	449438	3650693
12	NE	450238	3651493	34	NE	449838	3650893
	NW	450038	3651493		NW	449638	3650893
	SE	450238	3651293		SE	449838	3650693
	SW	450038	3651293		SW	449638	3650693
13	NE	450438	3651493	39	NE	450838	3650893
	NW	450238	3651493		NW	450638	3650893
	SE	450438	3651293		SE	450838	3650693
	SW	450238	3651293		SW	450638	3650693
14	NE	450638	3651493	40	NE	451038	3650893
	NW	450438	3651493		NW	450838	3650893
	SE	450638	3651293		SE	451038	3650693
	SW	450438	3651293		SW	450838	3650693
15	NE	450838	3651493	42	NE	449838	3650693
	NW	450638	3651493		NW	449638	3650693
	SE	450838	3651293		SE	449838	3650493
	SW	450638	3651293		SW	449638	3650493
20	NE	450238	3651293	44	NE	450238	3650693
	NW	450038	3651293		NW	450038	3650693
	SE	450238	3651093		SE	450238	3650493
	SW	450038	3651093		SW	450038	3650493
21	NE	450438	3651293	46	NE	450638	3650693
	NW	450238	3651293		NW	450438	3650693
	SE	450438	3651093		SE	450638	3650493
	SW	450238	3651093		SW	450438	3650493
24	NE	451038	3651293	47	NE	450838	3650693
	NW	450838	3651293		NW	450638	3650693
	SE	451038	3651093		SE	450838	3650493
	SW	450838	3651093		SW	450638	3650493
25	NE	449638	3651093	48	NE	451038	3650693
	NW	449438	3651093		NW	450838	3650693
	SE	449638	3650893		SE	451038	3650493
	SW	449438	3650893		SW	450838	3650493

Appendix I. UTM coordinates (NAD 83) for bird survey stations and transect sections, Casa Grande Ruins NM, 2001 and 2002. Accuracy is ± 15 m.

Plot type	Plot name	Point	Easting	Northing
Nocturnal survey	Owl	1	449489	3650899
		2	449892	3650877
		4	450692	3650907
		3	450287	3650908
Non-random VCP	Casa Grande	1	449800	3650680
		2	450147	3650682
		3	450493	3650687
		4	450844	3650692
		5	450693	3651011
		6	450344	3651009
		7	449992	3651027
		8	449636	3651016
		9	449813	3651311
		10	450163	3651310
		11	450515	3651312
		12	450865	3651304
Winter transect	CAGR	A	449797	3650678
		A-B midpoint	449923	3650673
		B	450049	3650667
		B-C midpoint	450176	3650681
		C	450303	3650694
		C-D midpoint	450428	3650683
		D	450553	3650672
		D-E midpoint	450678	3650681
		E	450803	3650690
		E-F midpoint	450780	3650812
		F	450757	3650934
		F-G midpoint	450639	3650973
		G	450520	3651011
		G-H midpoint	450396	3651012
		H	450272	3651013
		H-I midpoint	450147	3651020
		I	450021	3651026
		I-J midpoint	449897	3651010
		J	449772	3650993
		J-K midpoint	449782	3651117
		K	449792	3651241
		K-L midpoint	449917	3651256
		L	450042	3651270
		L-M midpoint	450165	3651297
		M	450288	3651323

Appendix J. UTM coordinates (NAD 83) for the southwest corner of small-mammal trapping plots, Casa Grande Ruins NM, 2002. Accuracy is ± 15 m.

Plot name	Easting	Northing
01	450444	3650529
02	450555	3651252
03	449548	3651002
04	450105	3650649
05	450110	3651341
06	450607	3650811
07	450114	3651142
08	450427	3650523
09	450685	3651133

Appendix K. Museums that were queried (in 1998) for vertebrate voucher specimens with "Arizona" and "Casa Grande Ruins" in the collection location. Collections in bold-faced type had specimens from Casa Grande Ruins NM.

Collections that had data for "Arizona:
Auburn University (AL) - herp data only
Chicago Academy of Sciences
Cincinnati Museum of Natural History & Science (OH) - all vertebrate data
Cornell Vertebrate Collections-Cornell University (Ithaca, NY) - mammal & bird-FTP
Field Museum of Natural History (Chicago, IL) - mammal data only
George Mason University (Fairfax, VA) - all vertebrate data
James Ford Bell Museum of Natural History-Univ. of MN (St. Paul) - mammal data only
Laboratory for Environmental Biology, Centennial Museum-The University of Texas at El Paso
Marjorie Barrick Museum at the University of Nevada-Las Vegas - bird and herp data
Michigan State University Museum (East Lansing) - all vertebrate data
Milwaukee Public Museum (WI) - all vertebrate data
Monte Bean Life Science Museum at Brigham Young University (Provo, UT)
Museum of Comparative Zoology, Harvard University (MA) - herp data only
Museum of Texas Tech University (Lubbock) - all vertebrate data
Museum of Natural History - University of Kansas - herp and mammal only
Museum of Vertebrate Zoology - Univ. of CA-Berkeley - all vertebrate data
Museum of Life Sciences-Louisiana State University@Shreveport - all vertebrate data
Natural History Museum of Los Angeles County (CA) - herp data only
New Mexico Museum of Natural History (Albuquerque)
North Carolina State Museum of Natural Sciences - bird and mammal data only
Oklahoma Museum of Natural History (Norman) - all vertebrate data
Peabody Museum-Yale University - all vertebrate data
Pipe Spring National Monument (National Park Service, AZ) - mammal data only
Saguaro National Park - all vertebrate data
Sharlot Hall Museum (Prescott, AZ)
Strecker Museum at Baylor University (Waco, TX) - all vertebrate data
Sunset Crater (National Park Service, Flagstaff, AZ)
Texas Cooperative Wildlife Collection - bird, herp, and mammal data
Tulane University Museum of Natural History (Belle Chasse, LA) - herp data only
University of Arizona- all vertebrates
University of Texas at Arlington (FTP'd data) - all vertebrate data
University of Illinois @ Champaign-Urbana - all vertebrate data
University of Michigan-Museum of Zoology - herp data only
University of Colorado Museum - all vertebrate data
Walnut Canyon (National Park Service, Flagstaff, AZ)
Western Archeological and Conservation Center (NPS, Tucson, AZ) - all vertebrate data
Wupatki National Monument (National Park Service, Flagstaff, AZ)

Appendix L. Voucher specimens from Casa Grande Ruins NM that were not collected by University of Arizona Inventory personnel. See Appendix K for list of collections that were queried for specimens with "Casa Grande Ruins" in the location field(s).

Taxon group	Common name	Scientific name	Collection	Catalog number	Date collected
Reptile	eastern kingsnake [a]	*Lampropeltis getulus*	Chicago Academy of Science	4701	August 1, 1938
	coachwhip	*Masticophis flagellum*	Chicago Academy of Science	16068	September 2, 1941
	spotted leaf-nose snake	*Phyllorhynchus decurtatus*	Chicago Academy of Science	7132	September 1, 1940
Mammal	western mastiff bat	*Eumops perotis*	University of Arizona	238	March 22, 1944
	western mastif bat	*Eumops perotis*	University of Arizona	916	March 22, 1944
	cottontail	*Sylvilagus species*	University of California, Berkeley	123191	April 20, 1905

[a] Identification questionable- most likely common kingsnake.

Appendix M. Photograph and specimen vouchers collected at Casa Grande Ruins NM by University of Arizona Inventory personnel, 2001 and 2002. All specimens are located in respective University of Arizona collections. See Appendices A–D for scientific names.

Group	Common name	Number of photo vouchers	Number of specimen vouchers	Catalog number(s)
Plant	night-blooming cereus	2		
Amphibian	Couch's spadefoot	1	1	
	Sonoran desert toad	1		
	Great Plains toad	1		
Reptile	western banded gecko	1		
	desert spiny lizard	2		
	common side-blotched lizard	1		
	long-tailed brush lizard	2		
	western (tiger) whiptail	2		
	coachwhip	1		
	gopher snake	2		
	common kingsnake	2		
	long-nosed snake	2		
	western diamond-backed rattlesnake	2		
	Mohave rattlesnake	3		
Bird	Harris's hawk	2		
Mammal	American badger		1	26771
	Arizona pocket mouse		2	26853, 26898
	Sonoran Desert pocket mouse		4	26917, 26892, 26920, 26918
	Merriam's kangaroo rat		3	26886, 26928, 26890
	deer mouse		1	26870
	southern grasshopper mouse		1	26849
	black-tailed jackrabbit	1		

Appendix N. Report by Phil Rosen[9] on the expected and historical occurrence of amphibian and reptiles of Casa Grande National Monument. Report date 6 August 2004.

The expected original herpetofauna of Casa Grande Ruins NM is primarily that of the Mohave Desert and Lower Colorado Valley province of the Sonoran Desert – the "true desert" herpetofauna of North America. The monument lies in the relatively less arid, northeastern region of the Mohave-Lower Colorado Valley herpetofaunal region, and is adjoining the Gila River, both factors tending to add elements of less xeric faunas – that of the thornscrub-like Arizona Upland floristic province of the Sonoran Desert, and that of the riparian and aquatic environments of the Gila River and its ancient canal system.

Thus, the expected original herpetofauna, while numerically dominated by true desert species, is increased by characteristic Arizona Upland species like the Sonoran desert toad, Mexican spadefoot, variable sand snake, southwestern black-headed snake, tree lizard, and Clark's spiny lizard, which also may be riparian associated, and regal horned lizard and saddled leaf-nosed snake, which are Arizona Upland but not riparian associated. In addition, certain aquatic- and stream-associated species such as the Woodhouse Toad, lowland leopard frog, checkered garter snake, Mexican garter snake, and Sonoran mud turtle may have or likely occurred at the site prior to upstream diversions of the Gila River.

The currently expected herpetofauna would not include any of the aquatic species, except perhaps the Woodhouse toad; would probably not include the riparian-associated species except perhaps the Sonoran desert toad; and, due to the surrounding environmental degradation, probably would not include the non-riparian Arizona Upland species. However, monument expansion or ecological restoration in the area could justifiably target habitat for any of these species as a benchmark or goal.

Associated with the monument's position near the transition from Lower Colorado Valley to Arizona Upland, to unique subspecies that have radically declined due to agriculture and, more recently, urbanization of the eastern Sonoran Desert, would be expected – the Tucson shovel-nosed snake (*Chionactis occipitalis klauberi*) and the Maricopa leaf-nosed snake (*Phyllorhynchus browni lucidus*).

Appendix E, showing museum records for the regional environs of Casa Grande National Monument, tends to bear out these expectations. Although most of the expected aquatic species were not recorded, this may reflect lack of collecting prior to the habitat degradation: Woodhouse toad and checkered garter snake were recorded, probably because they were originally abundant and can adapt to modern agriculture. Although the Mexican spadefoot was not in the sample for Appendix E, it was collected once just outside the area. Clark's spiny lizard, which was not found, probably is highly sensitive to riparian loss in such an arid region, and would not be expected to have survived nearby, even if it was once present.

Appendices B and E confirm the expectation that the monument's herpetofauna should be dominated by species characteristic of and abundant in the Lower Colorado Valley: lizards – side-blotched lizard, tiger whiptail, zebra-tailed lizard, desert iguana, western banded gecko, desert horned lizard, desert spiny lizard, and long-tailed brush lizard; snakes – sidewinder, gopher snake, glossy snake, and Mohave rattlesnake, as well as the occurrence of both the shovel-nosed and the leaf-nosed snakes. The proximity to Arizona Upland and former riparian conditions may

[9] Dr. Phil Rosen is an expert on the biogeography of Sonoran desert amphibians and reptiles.

be reflected in the abundance of such species as the long-nosed snake and western diamondback, and the presence of the saddled leaf-nosed snake, banded sand snake, southwestern black-headed snake, regal horned lizard, and tree lizard. Overall, the arid characteristic of the regional herpetofauna is well represented in Appendices B and E, and, at a minimum, most or all species abundantly represented in it might well be expected today in habitat like that found at the monument.

Thus, the loss of riparian-associated species is fully expected, and the absence of Arizona Upland species is not surprising, the recent lack of records for zebra-tailed lizard, desert iguana, and some other species suggests either more observation is needed, or, more likely, that effects of habitat fragmentation, isolation, and simplification may be fairly profound already at the monument. Other examples of species whose absence would suggest effects of small reserve size or habitat simplification at the monument include the leopard lizard, sidewinder, glossy snake, leaf-nosed snakes, and western shovel-nosed snake. Among these species, two that are difficult to find even if present, and that are represented by subspecies that may be globally threatened, are the saddled leaf-nosed snake (subspecies: Maricopa leaf-nosed snake) and western shovel-nosed snake (subspecies: Tucson shovel-nosed snake). These, along with other species listed in this paragraph, could be appropriate targets for an initial expansion of conservation efforts in the region of Casa Grande National Monument.

Appendix O. Frequency of detections of birds at each diurnal breeding-season survey station, Casa Grande Ruins NM, 2001 and 2002. Data are scaled by effort (sample size) and are from all observations made during eight-minute counts at stations (including flyovers and birds observed at unlimited distances). See Appendix I for station UTM coordinates and Appendix C for scientific names.

	Station (sample size)											
Common name	1 (*n* = 8)	2 (*n* = 8)	3 (*n* = 6)	4 (*n* = 5)	5 (*n* = 6)	6 (*n* = 8)	7 (*n* = 8)	8 (*n* = 8)	9 (*n* = 8)	10 (*n* = 8)	11 (*n* = 8)	12 (*n* = 5)
Gambel's quail	2.1	2.0	1.8	0.8		0.9	2.0	1.5	1.4	2.5	0.6	1.2
Swainson's hawk						0.1						
red-tailed hawk											0.1	
American kestrel	0.6	0.1					0.1		0.1	0.4	0.1	
prairie falcon									0.1	0.1		
sandhill crane			2.0									
killdeer		0.1										
black-necked stilt	0.3											
rock pigeon		1.0	4.3	14.4	0.5							0.4
white-winged dove		1.3	0.3	0.4	0.5		0.3	0.4	0.4		0.1	0.4
mourning dove	4.0	7.9	6.8	8.6	6.3	6.0	5.8	4.4	5.6	3.5	5.4	8.6
Inca dove	0.3											
burrowing owl			0.2		0.3				0.8		0.3	0.8
lesser nighthawk			0.5				0.1	0.1	0.1		0.1	
black-chinned hummingbird		0.4	0.3	1.8								
Anna's hummingbird	0.1	0.1		0.6		0.3	0.1	1.0		0.4		
Costa's hummingbird						0.1				0.1		
Gila woodpecker	0.6	0.1		0.2		0.1	0.6	0.6	0.5	0.1		
ladder-backed woodpecker							0.1					
gilded flicker	0.5	0.1	0.2		0.2	0.5	0.6	0.1	0.1	0.8	0.1	
western wood-pewee						0.1		0.1				
Say's phoebe						0.1						
ash-throated flycatcher			0.2		0.3	0.4	0.4	0.1	0.3	0.3	0.4	0.2
western kingbird	0.1				0.2	0.3			0.1		0.1	0.4
loggerhead shrike		0.1						0.1	0.3			
common raven							0.1				0.3	0.4
horned lark					0.2	0.1		0.5	1.5			0.4
cliff swallow	9.6	0.4	0.2	1.2	0.3	0.4	4.4	6.0	11.3		0.1	
verdin	0.3	0.5		0.2	0.2		0.3			0.3		0.6
cactus wren	0.8	0.3	0.3				0.3	0.6	0.1			0.2
northern mockingbird	0.1	0.4	0.5	0.8	0.5	0.3	0.3	0.1		0.1	0.1	0.6
curve-billed thrasher			0.2									
European starling	3.9	0.5					0.4	1.5				1.4
American pipit							0.1					
yellow warbler				0.2								
MacGillivray's warbler										0.1		
Wilson's warbler										0.3		
western tanager				0.2								
chipping sparrow						0.3						
Brewer's sparrow		1.0	1.2		0.2	3.6	1.8	1.6		3.1	3.8	
vesper sparrow										0.1		
lark sparrow			0.3									
lark bunting								8.1	1.5			
red-winged blackbird	3.9		0.5	0.4	1.0	0.6	0.1	0.4	4.6	0.5	0.9	0.2
great-tailed grackle	1.6	2.0	2.5	5.2	0.8	0.5	0.5	1.8	0.4	0.4	0.5	0.8
brown-headed cowbird	0.3	0.3										

	Station (sample size)											
Common name	1 (*n* = 8)	2 (*n* = 8)	3 (*n* = 6)	4 (*n* = 5)	5 (*n* = 6)	6 (*n* = 8)	7 (*n* = 8)	8 (*n* = 8)	9 (*n* = 8)	10 (*n* = 8)	11 (*n* = 8)	12 (*n* = 5)
Bullock's oriole						0.1						
house finch	5.6	1.1	0.3	1.2	1.0	1.3	1.6	1.1	1.8	1.3	0.3	1.0
lesser goldfinch				0.4			0.1					
house sparrow	3.1	1.1	1.8	2.0	1.5	0.8	0.8	1.1	0.1		1.1	
Number of species	**19**	**21**	**20**	**17**	**16**	**21**	**23**	**21**	**20**	**18**	**18**	**16**

Appendix P. Sum and mean frequency of detection (FD) of all bird observations from diurnal breeding-season surveys during four, two-week time periods, Casa Grande Ruins NM, 2001 and 2002. Sample sizes (*n*) are the number of stations surveyed during that time period. See Appendix C for scientific names.

	Time period							
	April 15-31 (*n* = 44)		May 1-15 (*n* = 12)		May 16-31 (*n* = 20)		June 1-15 (*n* = 10)	
Common name	Sum	FD	Sum	FD	Sum	FD	Sum	FD
mallard	4	0.09						
Gambel's quail	82	1.86	22	1.83	30	1.50	6	0.60
northern harrier	1	0.02						
Swainson's hawk	1	0.02						
red-tailed hawk	1	0.02						
American kestrel	6	0.14			6	0.30	3	0.30
prairie falcon	1	0.02			1	0.05		
sandhill crane	12	0.27						
killdeer	1	0.02						
black-necked stilt			2	0.17				
rock pigeon	70	1.59	25	2.08	12	0.60	6	0.60
white-winged dove	20	0.45	8	0.67	3	0.15	2	0.20
mourning dove	228	5.18	145	12.08	103	5.15	31	3.10
Inca dove	2	0.05						
greater roadrunner	1	0.02						
burrowing owl	5	0.11	4	0.33	4	0.20	4	0.40
lesser nighthawk	2	0.05	2	0.17	4	0.20	5	0.50
black-chinned hummingbird	6	0.14	3	0.25	5	0.25		
Anna's hummingbird	12	0.27	2	0.17	5	0.25	1	0.10
Costa's hummingbird	2	0.05						
Gila woodpecker	15	0.34	4	0.33	4	0.20		
ladder-backed woodpecker			1	0.08				
gilded flicker	2	0.05	11	0.92	6	0.30	10	1.00
western wood-pewee			2	0.17	1	0.05		
gray flycatcher	1	0.02						
Say's phoebe	1	0.02						
ash-throated flycatcher	9	0.20	3	0.25	4	0.20	3	0.30
western kingbird	6	0.14	3	0.25	1	0.05	1	0.10
loggerhead shrike	1	0.02			2	0.10	1	0.10
common raven	3	0.07	3	0.25				
horned lark	7	0.16	4	0.33	6	0.30	7	0.70
cliff swallow	11	0.25	306	25.50	17	0.85	1	0.10
verdin	8	0.18	3	0.25	3	0.15	1	0.10
cactus wren	13	0.30	2	0.17	2	0.10	2	0.20
black-tailed gnatcatcher					1	0.05		
northern mockingbird	16	0.36	4	0.33	5	0.25		
curve-billed thrasher	1	0.02						
European starling	35	0.80	13	1.08	7	0.35	4	0.40
American pipit			1	0.08				
phainopepla					1	0.05		
orange-crowned warbler	1	0.02						
Nashville warbler	1	0.02						
Virginia's warbler	1	0.02						
Lucy's warbler	1	0.02						
yellow warbler			1	0.08				
yellow-rumped warbler	3	0.07						

	Time period							
	April 15-31 (*n* = 44)		May 1-15 (*n* = 12)		May 16-31 (*n* = 20)		June 1-15 (*n* = 10)	
Common name	Sum	FD	Sum	FD	Sum	FD	Sum	FD
MacGillivray's warbler			1	0.08				
Wilson's warbler	2	0.05	1	0.08				
western tanager			1	0.08				
green-tailed towhee	1	0.02						
chipping sparrow	4	0.09						
Brewer's sparrow	130	2.95						
vesper sparrow	1	0.02						
lark sparrow	2	0.05						
lark bunting	77	1.75						
white-crowned sparrow	3	0.07						
red-winged blackbird	61	1.39	33	2.75	10	0.50	2	0.20
great-tailed grackle	45	1.02	39	3.25	23	1.15	4	0.40
brown-headed cowbird	3	0.07			1	0.05		
Bullock's oriole	4	0.09	1	0.08				
house finch	44	1.00	29	2.42	49	2.45	9	0.90
lesser goldfinch	1	0.02	2	0.17				
house sparrow	33	0.75	31	2.58	26	1.30	5	0.50
Number of species	**54**		**33**		**29**		**21**	

Appendix Q. Summary of vegetation characteristics measured at bird survey stations, Casa Grande Ruins NM, 2002. See Appendix A for list of scientific names of plants.

				Distance from subpoint		Plant height		Canopy diameter	
Station	Category	Common name	N	Mean	SE	Mean	SE	Mean	SE
1	Subshrub	creosote bush	17	22	4.2	0.8	0.05	0.8	0.09
	Shrub	creosote bush	20	10	2.6	1.8	0.09	2.2	0.15
	Tree	saguaro	1	85		6.0		3.0	
		creosote bush	11	27	4.8	2.8	0.08	3.6	0.24
		velvet mesquite	8	60	19.3	4.7	0.29	5.1	0.51
	Cavity	saguaro	3	121	22.0	6.0	0.00	2.7	0.13
		candy barrel cactus	2	82	58.5	1.6	0.00	0.5	0.05
		velvet mesquite	14	60	10.0	5.9	0.63	7.4	0.62
2	Subshrub	candy barrel cactus	1	14		0.5		0.4	
		creosote bush	19	14	2.8	0.7	0.06	0.6	0.06
	Shrub	creosote bush	20	3	0.3	1.5	0.07	1.6	0.11
	Tree	creosote bush	14	37	5.0	2.8	0.08	3.0	0.20
		velvet mesquite	6	45	8.8	3.8	0.31	3.5	0.57
	Cavity	velvet mesquite	20	32	3.2	2.9	0.17	5.0	0.44
6	Subshrub	creosote bush	20	6	1.2	0.8	0.04	0.8	0.06
	Shrub	creosote bush	20	3	0.5	1.4	0.07	1.7	0.18
	Tree	creosote bush	12	46	7.8	2.7	0.04	2.7	0.18
		velvet mesquite	8	77	13.8	4.4	0.18	4.8	0.28
	Cavity	velvet mesquite	19	29	2.8	2.4	0.19	3.7	0.39
8	Subshrub	fourwing saltbush	7	10	1.4	0.7	0.08	0.9	0.22
		creosote bush	13	24	5.1	0.8	0.04	0.6	0.10
	Shrub	fourwing saltbush	1	25		1.0		1.4	
		creosote bush	19	10	1.9	1.8	0.08	2.1	0.21
	Tree	creosote bush	17	41	7.4	2.9	0.06	2.7	0.15
		velvet mesquite	2	8	0.5	5.4	1.40	7.5	1.50
		Lycium species	1	8		3.1		5.0	
	Cavity	candy barrel cactus	1	25		1.6		0.4	
		velvet mesquite	19	48	7.2	3.1	0.19	4.8	0.70
11	Subshrub	creosote bush	20	9	0.7	0.9	0.03	0.7	0.08
	Shrub	creosote bush	20	4	0.4	1.6	0.08	1.8	0.12
	Tree	creosote bush	13	52	10.4	2.6	0.02	2.1	0.05
		velvet mesquite	1	175		3.1		2.2	
	Cavity	velvet mesquite	15	51	13.5	2.7	0.18	2.6	0.26
12	Subshrub	creosote bush	18	8	1.1	0.9	0.04	0.8	0.08
	Shrub	creosote bush	20	3	0.4	1.7	0.09	2.0	0.12
	Tree	creosote bush	14	25	4.8	2.7	0.03	2.4	0.15
		velvet mesquite	6	94	16.3	4.2	0.19	4.0	0.42
	Cavity	velvet mesquite	20	26	3.1	2.0	0.18	3.2	0.30

	Mean vegetation volume (%)			Coverage (%)		
Station	0–0.5 m	>0.5–2.0 m	>2.0 m	Litter	Bare ground	Rocks
1	7	6	1	9	89	0
2	11	10	1	11	89	0
6	13	8	0	10	90	0
8	7	3	1	16	83	0
11	14	10	0	10	90	0
12	16	10	1	15	84	0